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A Remarkable Textbook

Barber's First Course in General Science

By FREDERICK D. BARBER, Professor of Physics in the Illinois State Normal University, MERTON L. FULLER, Lecturer on Meteorology in the Bradley Polytechnic Institute, JOHN L. PRICER, Professor of Biology in the Illinois State Normal University, and HOWARD W. ADAMS, Professor of Chemistry in the same. vii+588 pp. of text. 12mo. $1.25.

A recent notable endorsement of this book occurred in Minneapolis. A Committee on General Science, representing each High School in the city, was asked to outline a course in Science for first year High School. After making the outline they considered the textbook situation. In this regard, the Committee reports as follows:

"We feel that, in Science, a book for first year High School use should be simple in language, should begin without presupposing too much knowledge on the part of the student, should have an abundance of good pictures and plen[illegible] of material to choose from.

Barber's *First Course in General Science* seems to us to be[illegible] meet these requirements and in addition it suggests materials for home experiments requiring no unusual apparatus, and requires no scientific measurements during the course. We recommend its adoption."

Other Interesting Opinions on the Book Follow:

SCHOOL SCIENCE AND MATHEMATICS:—It is one of the very best books on general science that have ever been published. The biological as well as the physical side of the subject is treated with great fairness. There is more material in the text than can be well used in one year's work on the subject. This is, however, a good fault, as it gives the instructor a wide range of subjects. The book is written in a style which will at once command not only the attention of the teacher, but that of the pupil as well. It is interesting from cover to cover. Many new and ingenious features are presented. The drawings and halftones have been selected for the purpose of illustrating points in the text, as well as for the purpose of attracting the pupil and holding his attention. There are 375 of these illustrations. There is no end to the good things which might be said concerning this volume, and the advice of the writer to any school board about to adopt a text in general science is to become thoroughly familiar with this book before making a final decision.

WALTER BARR, *Keokuk, Iowa*:—Today when I showed Barber's Science to the manager and department heads of the Mississippi River Power Co., including probably the best engineers of America possible to assemble accidentally as a group, the exclamation around the table was: "If we only could have had a book like this when we were in school." Something similar in my own mind caused me to determine to give the book to my own son altho he is in only the eighth grade.

G. M. WILSON, *Iowa State College*:—I have not been particularly favorable to the general science idea, but I am satisfied now that this was due to the kind of texts which came to my attention and the way it happened to be handled in places where I had knowledge of its teaching. I am satisfied that Professor Barber, in this volume, has the work started on the right idea. It is meant to be useful, practical material closely connected with explanation of every day affairs. It seems to me an unusual contribution along this line. It will mean, of course, that others will follow, and that we may hope to have general science work put on such a practical basis that it will win a permanent place in the schools.

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THE SCIENTIFIC MONTHLY

JANUARY, 1918

MODERN NATURAL HISTORY MUSEUMS AND THEIR RELATION TO PUBLIC EDUCATION

By Dr. BARTON WARREN EVERMANN

DIRECTOR OF THE MUSEUM OF THE CALIFORNIA ACADEMY OF SCIENCES

I WISH to make a plea in behalf of the educational value of natural history museums. The place of the museum in public education is not even yet fully appreciated, either in this country or in Europe, by the general public or even by the most intelligent classes. A striking illustration of this fact is found in the recent proposed action of the British government to close all museums and art galleries. The Retrenchment Committee of the House of Commons, in order that the resources of the country might not be used except for the really essential things in this distressing time of war, recommended the closing of all the national museums in London, except the reading room at the British Museum, parts of the National Gallery, and the Victoria and Albert Museum. The proposed action was justified on the ground that a saving of 5,000 pounds could be made, that the museum employees would then be available for war service, and that museums are, primarily, merely "places of pleasant resort," anyhow! Such a strong protest was made, however, that the order was materially modified.

Museums had their origin in the effort to preserve and care for the rare and curious objects which travelers brought home from distant lands. Collecting rare and strange objects was first raised to the dignity of a fine art in Italy. The Medici at Florence and the Estes at Modena were the first; they set the example which in time spread throughout Europe.

But the collectors of those days were rarely imbued with the scientific spirit; their motives were largely selfish. They were usually wealthy and cultivated amateurs who assembled and maintained collections for their own pleasure and glorification.

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FIG. 1. SAN JOAQUIN VALLEY ELK (*Cervus nannodes*)

This beautiful animal, sometimes known as the Tule Elk or Dwarf Elk, formerly ranged in vast numbers through the San Joaquin-Sacramento Valley. Only a few hundred now remain. That the species is not entirely extinct is due to the foresight and interest of the late Henry Miller, founder of the great cattle company of Miller and Lux. In the early seventies, when only a few individuals were left, the herd made its last stand on the Kern County ranch of Miller and Lux. Mr. Miller instructed his cattlemen not to disturb the elk in any way. His instructions were carried out and now the herd is in a very prosperous condition. Recently the California Academy of Sciences, with the assistance of Messrs. Miller and Lux, caught and distributed 150 of these Elk to a dozen or more large public or private parks or reservations in California where the conditions are favorable for the increase of the species. Background by Charles Abel Corwin.

It was not until 1753 when the British Museum was established at Bloomsbury and the collections of Sir Hans Sloane acquired, that the idea of a public museum emerged. It was then realized, apparently for the first time, that a museum, to advance art and scientific knowledge, must be liberally endowed, or else fostered by the state. But the founding and development of museums up to recent times need not detain us. With the founding of the British Museum in 1753 and the National Museum at Washington nearly a century later, the idea of the public museum may be said to have become firmly established.

In discussing the development of the United States National Museum Dr. G. Brown Goode considered the history of that institution as falling into three periods:

First, the period from the founding of the Smithsonian Institution to 1857, during which time specimens were collected solely to serve as materials for research. No special effort was made to exhibit them to the public or to utilize them, except as a foundation for scientific description and theory.

Second, the period from 1857 to 1876, during which the museum became a place of deposit for scientific collections which had already been studied, these collections, so far as convenient, being exhibited to the public and, so far as practicable, made to serve an educational purpose.

Third, the present period (beginning with 1876) in which the museum has undertaken more fully the additional task of gathering collections and exhibiting them on account of their value from an educational standpoint.

During the first period the main object of the museum was scientific research; in the second, the establishment became a museum of record as well as research; while in the third period has been added the idea of public education. The three ideas—record, research and education—cooperative and mutually helpful as they are, are essential to the development of every great museum.

Dr. Goode regarded the National Museum first, as *a museum of record*, in which are preserved the material foundations of an enormous amount of scientific knowledge—the types of numerous past investigations; second, as *a museum of research*, which aims to make its contents serve in the highest degree as a stimulus to inquiry and a foundation for scientific investigation; and third, as *an educational museum*, through its policy of illustrating by specimens every kind of natural object and every manifestation of human thought and activity, of displaying

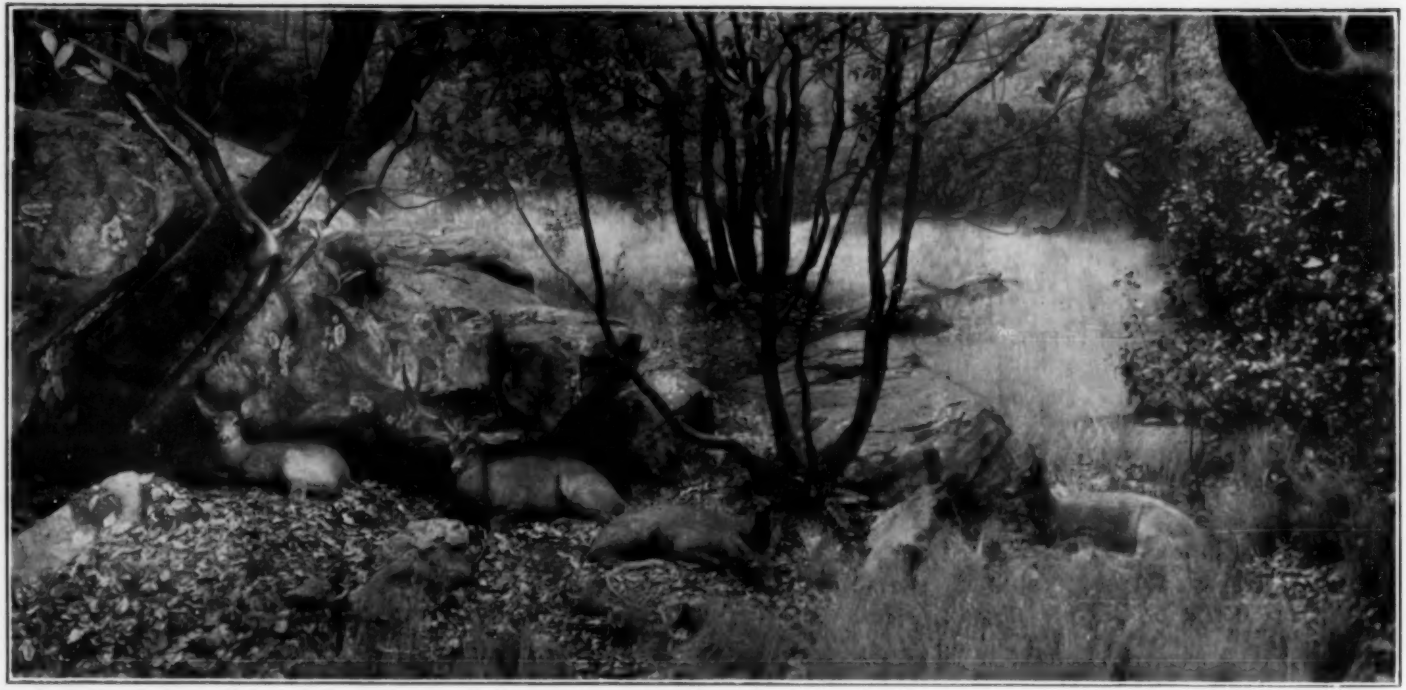

FIG. 2. COLUMBIAN BLACK-TAILED DEER (*Odocoileus columbarius*)

This group represents a summer scene in Mendocino County, California, where the deer shown were taken. At this season the deer assume what is known as the "red coat," which is gradually shed, changing to the bluish coat. The hair then becomes grayer in color as it lengthens for the winter months. In the spring the long hairs of the winter coat are shed and again replaced by the short red coat of summer.

The horns are shed annually, usually in February and March. The entire antler drops off from the skull at the base of the horn or "burr." A new horn sprouts out from the skull and, normally, develops into the antler characteristic of the species. The common belief that a deer develops a new point on the antlers each year and that the number of points indicates the age of the animal is erroneous. Background by Charles Abel Corwin.

descriptive labels adapted to the popular mind, and of distributing its publications and its named series of duplicates. This admirable statement of the scope and objects of the National Museum, made by Dr. Goode twenty years ago, still applies in its general terms to that institution, and equally well to a number of other museums in America.

The one thing which will most strongly impress any one who visits the museums of the east is their activity along educational lines, and the ways in which they are endeavoring to interest the public, and to be of service to the community. It is apparent that the museums of the east are realizing more and more that they owe a debt to the public and to those who have made their existence possible. Until recently most museums have done little or nothing in respect to general education.

> They have been content to be merely vast depositories for collections of priceless value, either unseen or gazed upon in mute wonder by those who visited them.

In such museums visitors "wander listlessly and aimlessly about the halls and galleries, with little appreciation and scarcely any understanding of the treasures that surround them."

But a great change has come about within the last few years. Now, the museum has come to regard itself, and to be regarded by the public, as an educational institution, working in cooperation with the public and private schools, for the good of all the children who can be brought within its influence. It is now realized that a public museum, in order to justify its existence, must be of real service, not only to investigators, but to the general public as well.

To meet the needs of the investigator, the museum must be an institution for research, an institution for the advancement of knowledge and its diffusion among men. A museum furnishes facilities for research and the acquirement of knowledge through, and in proportion to the completeness of, its research collections, and the encouragement it gives to field and laboratory investigations. The knowledge acquired by its investigators through field and laboratory investigations and studies is made known to the world chiefly through the medium of the museum's publications.

The second function of a public museum—perhaps, I may say, the most important function, because it may be regarded as including the first—is that of usefulness to the public in an educational way. Not until recently has this function been fully realized or received attention; but now it is the dominant and

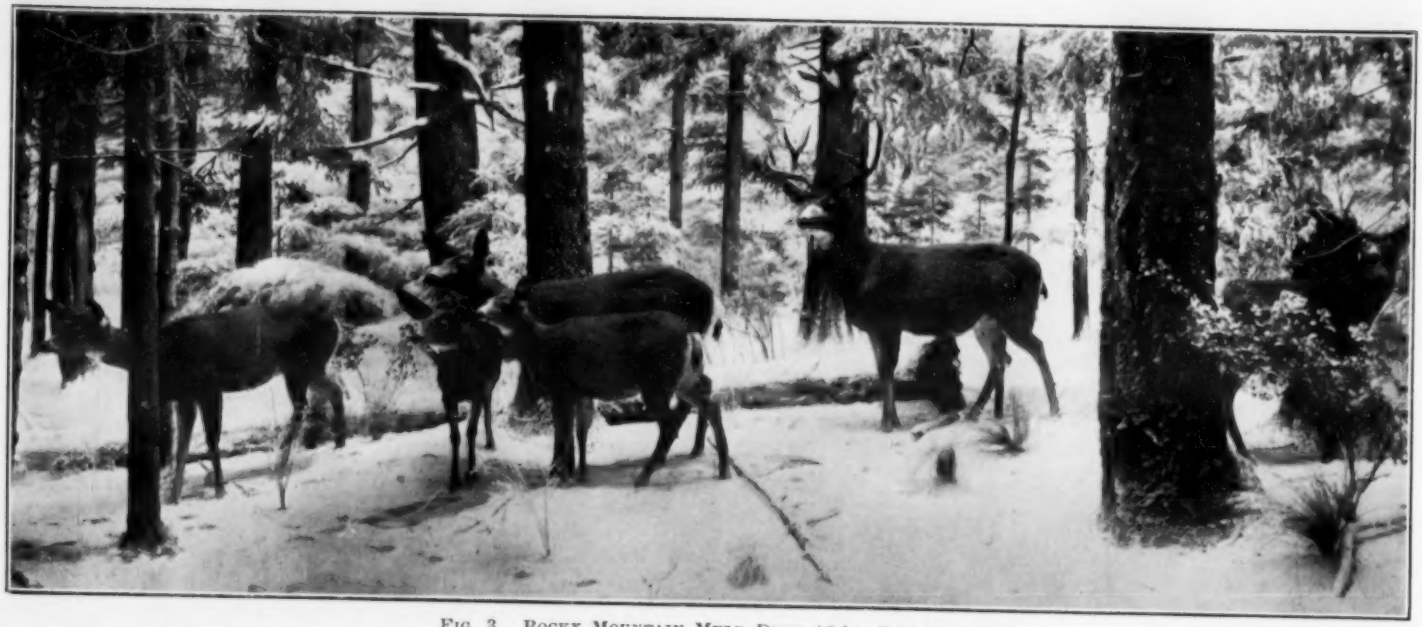

FIG. 3. ROCKY MOUNTAIN MULE DEER (*Odocoileus hemionus*)

This splendid deer is of wide distribution. In California it is found in the Sierras from Kern County northward, coming to the coast in the northern counties. The animals here shown were taken in Siskiyou County, California, in October. This is the largest of the North American deer, the adult male in prime condition weighing nearly 400 pounds. The name "mule deer" is sometimes applied to this species because of its long ears and its mule-like tail. Background painted by Charles Abel Corwin.

controlling thought in many of our museums, great and small.

It is true that most museums, from the very beginning, have maintained considerable collections of natural history objects, and specimens of other kinds, which the visitor might see; but as Director Lucas, of the American Museum of Natural History, has so well said,

> The visitor was greeted by row upon row of animals, most literally stuffed, arrayed in ranks and accompanied by labels whose principal mission was to convey to the public what to them is a most unimportant matter, the scientific names.

But this is not our conception of the modern natural history museum; nor is the modern museum merely a "Haunt of the Muses." It is more than that. It must be not only a place "dedicated to the cultivation of learning" and frequented by men and women devoted to learning and the improvement of human knowledge, but it should be a treasure-house of specimens of the animals, plants and other natural objects of the world, and of objects illustrative of the activities of the races of men.

The educational idea has taken firm hold on many of our American museums. It is manifesting itself in activities along a number of lines, the principal of which are:

1. The installation of large habitat and ecological groups of birds, mammals, etc.

2. The preparation of portable habitat groups for loan to public and private schools.

3. The maintenance at the museum of courses of lectures on natural history, and other subjects adapted to the needs of school children of the different grades.

I can probably best show what this idea is and what a firm hold it has by briefly telling how it is worked out in certain of our more active institutions.

Habitat Groups.—Perhaps the greatest advance of recent years in making museums really educational is in the matter of the installation of exhibits of animals and plants. The improvement has been chiefly with habitat and ecological groups, in giving the animals their natural surroundings, placing them in their natural environment. Until recently in most museums (and in some even to this day) the exhibition specimens of birds and mammals were fastened to a board of some kind and then placed in glass cases, usually against the wall, with no accessories whatever about them, even to suggest in what sorts of places they could be found alive. Now, all that is changed. The species to be shown is shown as a group of individuals—a pair of adults (male and female), one or more young, the nest if it be

FIG. 4. ANTELOPE (*Antilocapra americana*)

The antelope or pronghorn formerly ranged in immense numbers over the plains and valleys of North America west of the Mississippi River from Mexico to Canada. In California great herds were found throughout the Sacramento and San Joaquin valleys and in other valleys to the north, east and south. As a result of persistent persecution and slaughter for their hides and meat, these animals have, in most parts of their range, been entirely exterminated. In southeastern Oregon and northwestern Nevada they are still common. In California small isolated bands are still left. In all these states they are protected by law. The antelope is the only member of the hollow-horned animals which annually sheds its horns. Only the outer shell or sheath, however, is shed, and not the entire horn, as in the deer and elk. The antelope is also unique in not possessing dew claws or accessory hoofs on the backs of the feet, as in the deer. The background was painted by Charles Abel Corwin.

a bird, the den in many species if it be a mammal, and the group surrounded by the trees and shrubs, annual plants, and other objects which together make up a bit of just such landscape as you would find the animals in should you seek them alive and in their natural habitat. As only a limited amount or number of units of the environment can be shown by means of the real objects, the setting is made more complete by means of a painted background, the real and the painted being so joined as to make it difficult, in most cases impossible, to tell where the real ends and the painting begins. Along with this improved installation of the group, the problem of proper lighting has also been more satisfactorily solved, as I shall explain later. Among museums which have given special attention to habitat groups I may mention the American Museum of Natural History in New York, the Brooklyn Museum, the Field Museum in Chicago, the Chicago Academy of Sciences, the Milwaukee Public Museum, and the University of Iowa.

Lectures.—A second way in which modern museums are rendering real service to the community is through the medium of public lectures at the museum, on natural history or other scientific subjects of popular or general interest. Not only are courses of lectures provided for adults, but, of greater importance, courses are provided to meet the needs of the different school grades. The lectures usually relate to subjects for which there is found in the museum illustrative material. Instead of the children coming to the museum and wandering through the halls without any real, definite object in view, they are, through observation and explanatory lectures, led to a fuller appreciation of the museum exhibits.

A definite plan of cooperation with the public schools is, of course, necessary. The lectures are upon subjects that form a regular part of the school curriculum. They are adapted to the needs and understanding of the children of the different grades and the courses are maintained throughout the school year. On one day the lecture will be given to, say, fourth-grade pupils; on other days to other grades. The lecturer may give the same lecture three or four times the same afternoon, to as many different groups of fourth-grade children, because all the children of any one grade in the city make too large a number to be accommodated at one time. Definite arrangements are made with the school authorities as to the order in which the classes are to come. The next day, fifth-grade pupils may come, the next day, sixth, and so on.

The American Museum of Natural History in New York

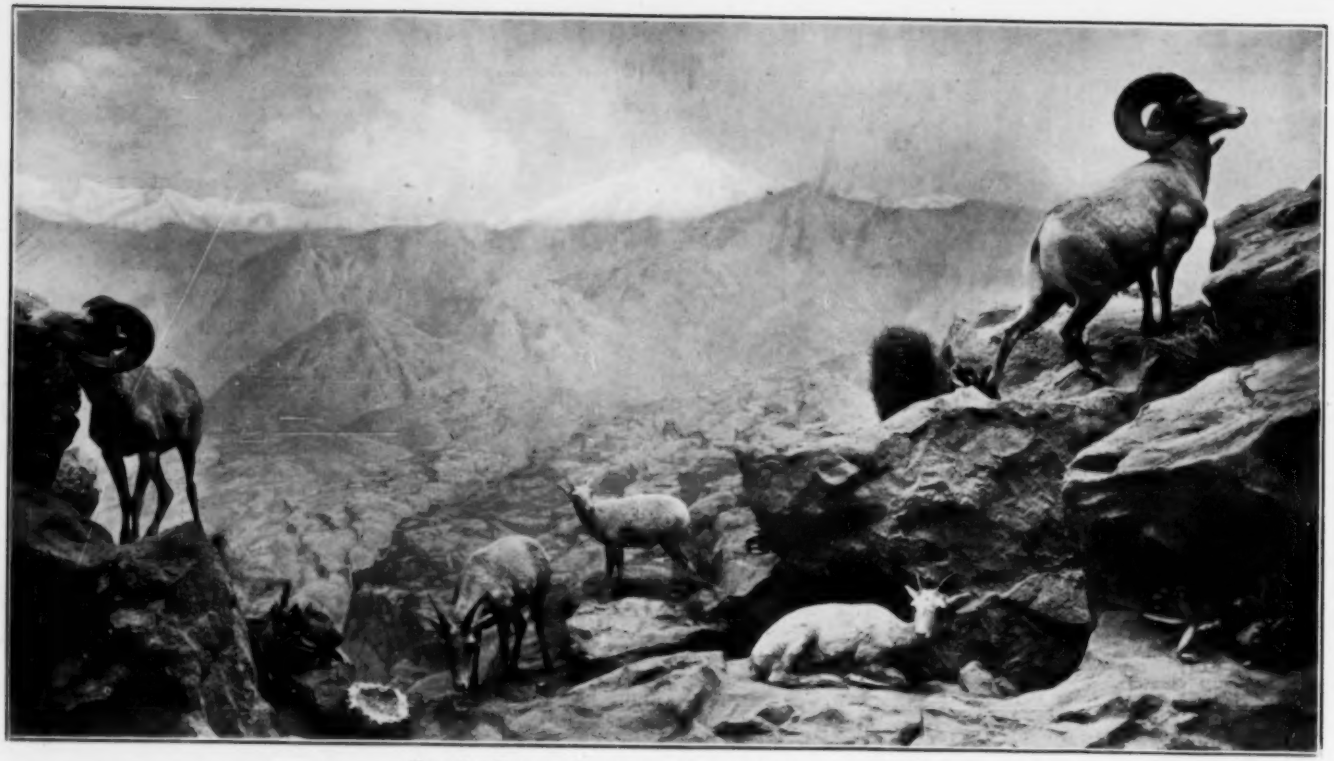

FIG. 5. DESERT MOUNTAIN SHEEP (*Ovis cremnobates*)

This species of mountain sheep or bighorn is found in the desert mountains of southern California and adjacent parts of Nevada, Arizona and Mexico. The animals in this group were taken in December, 1913, in the San Jacinto Mountains, Riverside County, California. The slender horns of the females have given rise to the mistaken belief that the ibex—an animal found only in Europe and Asia—is found in America. The story that mountain sheep sometimes jump from high precipices and alight on their horns is entirely erroneous, and is on a par with the hoopsnake, sea serpent and other similar stories. In the desert mountains water is usually scarce, and the mountain sheep frequently eat the barrel cactus, the pulpy interior of which contains a large percentage of water; and this no doubt enables the sheep to go for long periods without drinking. Background painted by Charles Abel Corwin.

and the Milwaukee Public Museum have perhaps been most active in the matter of lectures. The lectures given deal with various subjects, as geography, American history, birds of our parks, fur-bearing animals found within 50 miles of the museum, wild flowers of the vicinity, public health, and many other subjects. All the lectures are illustrated by materials and specimens in the museum, by appropriate stereopticon slides (of which each of these museums possesses many thousands), and by moving pictures, photographs and other illustrations. These museums each now maintain a regular department of public education with a competent curator and expert lecturers. Many thousand children attend the lectures, and excellent results are accomplished. Similar excellent work is being done by other institutions.

Although the lecture courses have proved very successful and reach a large percentage of the pupils, they do not and can not reach all. In a large city it is impracticable for the children in the remote, more distant schools to reach the museum. The time required to make the journey to the museum, then back to the school, and the expense involved, are too great. Many children can not afford the cost of car fares. To meet this difficulty it was felt that if the children could not come to the museum, the museum should be sent to the children; and this was done by providing traveling or circulating exhibits or collections, usually called

Loan Exhibits.—These may be habitat groups of small mammals, birds or other animals; minerals, plants, woods and various other objects. For example, it may be a California Quail group showing a pair of adult birds, their nest and young, together with the appropriate surroundings; or it may be a field mouse, adults, nest and young, and the sort of place in which they are naturally found. The case containing the group is small enough to be handled readily, and is made so as to appear attractive. A label accompanies each case, giving the information that school children would naturally wish to know regarding the species. These portable exhibits are loaned to the public schools and are used by the teachers in their nature work and object-lesson teaching. In making up the groups the school authorities are consulted and such groups are prepared as fit into the regular school curriculum.

This is perhaps the most effective way in which the museum can cooperate with the public schools. Several museums are doing excellent work in this line, among which I must mention particularly the Field Museum in Chicago and the American

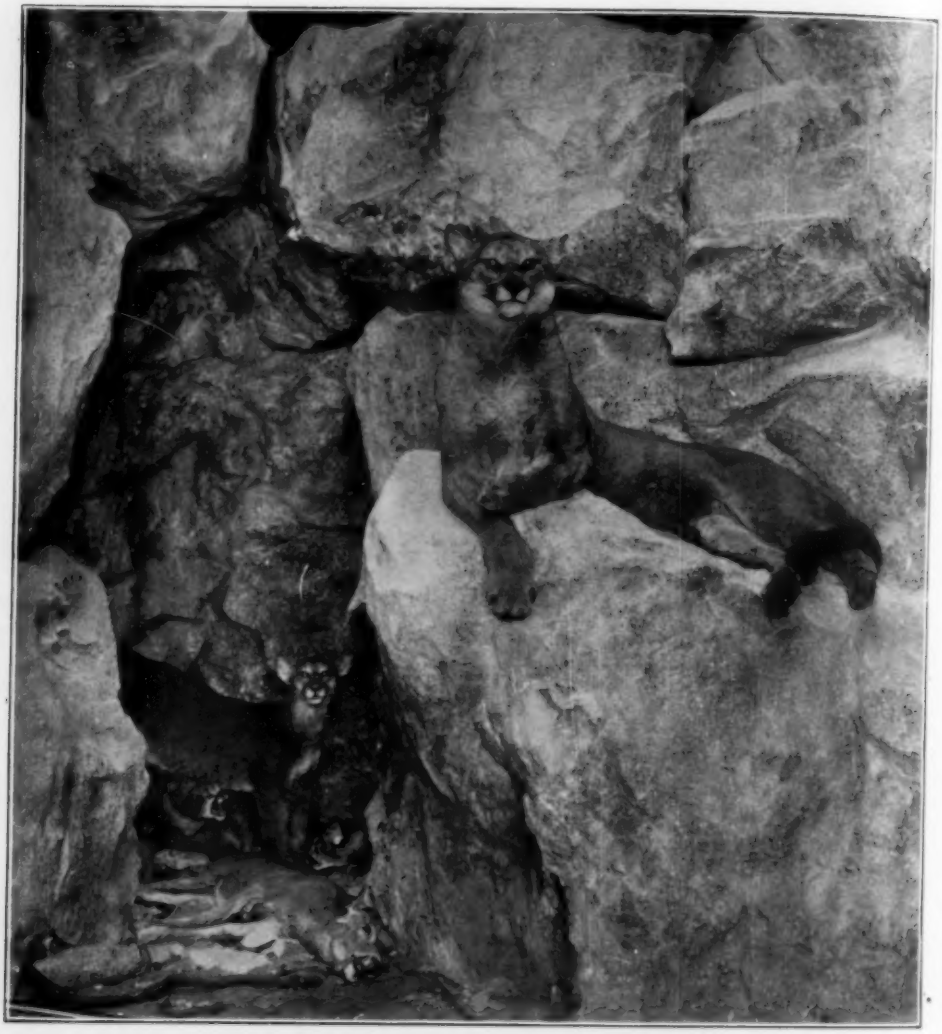

FIG. 6. MOUNTAIN LION (*Felis oregonensis*)

The mountain lion, in its various forms, is found from Patagonia to Canada, and from the Atlantic to the Pacific. In different parts of its range it is known by different names, as, panther, "painter," cougar, etc. Although not so common as formerly it is still plentiful in certain sections of California, especially in the northern part of the state. The animals in this group were taken in Humboldt County. The mountain lion is the largest of the North American cats. It is very destructive to deer and certain domestic animals, particularly colts and sheep. It has been estimated that each lion in California kills on an average one deer a week throughout the year. So destructive is it that the state pays a bounty of $20 each for its capture. Up to June 30, 1916, the state had paid bounties on 2,534 lions. Although the mountain lion is looked upon as a very fierce animal and more or less of a menace to human beings, it is really a very wary animal, and instances of its attacking man are rare indeed. It is generally easy to tree, even with a cur dog, and chasing it with dogs is the method usually employed in its capture.

Museum of Natural History in New York. A few years ago the Field Museum began this work on a small scale. A public-spirited citizen, Mr. N. W. Harris, saw what they were doing and became deeply interested. Mr. Harris is a man of vision. He at once saw the wonderful possibilities of this method of teaching and the good results that can come from cooperation with the public schools. After investigating the matter carefully, he decided to give to the Field Museum the sum of $250,000 as an endowment for educational work of this kind. With this fund there was established "The N. W. Harris Public School Extension of Field Museum of Natural History." The entire income of this endowment is devoted to educational work. Habitat groups of convenient size and form, attractive in appearance, and such as will teach lessons of real value to the children, are provided in large numbers. Economic collections, such as illustrate or relate to the practical phases of natural production and distribution, geography and commerce, are also made use of. These exhibits are distributed by automobile to the various schools where they are placed in the care of the principals. The cases are allowed to be retained two weeks, and then sent on to the next school on the list. The American Museum of Natural History is also doing the same thing and with very gratifying results.

This practise of sending the museum to the schools, instead of having the school children come to the museum, has the advantage of making it possible to reach a larger number of pupils than could otherwise be reached, and it is more economical of the time of the pupils and teachers. It also makes it easier for the teacher to make the lesson more concrete and more effective.

May I be permitted at this time to speak particularly of the Museum of the California Academy of Sciences and what it is trying to do in the interest of public education. Although the California Academy of Sciences was founded in 1853, just 100 years after the founding of the British Museum of Natural History at Bloomsbury, it was not until recently that any definite attempt was made by it to develop a museum along educational lines. The Museum of the California Academy of Sciences, speaking broadly, feels that it has two primary functions—to promote scientific research with special reference to making known the natural resources of California and the other Pacific coast states, and second, to aid, as best it may, in public education in natural history and other science subjects.

In furtherance of these objects the academy has recently built the first unit of a new museum building in Golden Gate

FIG. 7. NORTHWESTERN BLACK BEAR (*Ursus americanus albifrontalis*)

The black bear in its various forms ranges generally from the Atlantic to the Pacific and from northern Mexico to Alaska. The specimens in this group were taken in Humboldt County, California. In California, as elsewhere, the black bear may be either black or brown. In some instances both black and brown cubs are found in the same litter, and with either a black or a brown mother. Brown bears are sometimes confused with the grizzly which is now believed to be extinct in California. Black bears occasionally kill sheep and pigs, but they live chiefly on nuts, roots and berries; grubs, worms, and insects also enter largely into their menu. As a rule the black bear is a wary animal and will rarely or never attack a man unless wounded or cornered. From one to four cubs (usually one or two) are produced in a litter. The cubs are usually born in January (in California) and are helpless little creatures; their eyes, like those of puppies and kittens, are closed and do not open for some time. They have no teeth and are almost naked. Although the mother bear may weigh three or four hundred pounds, the whole litter of cubs will weigh less than a pound. The cubs shown in this group were about two months old when taken.

Park. This unit, known as the West Wing, consists of a front hall 180 feet long by 60 feet wide, with two rear wings each 128 feet long by 60 feet wide, with a court 70 feet wide between them. Tying the two rear wings to the front is a connecting hall 180 feet long by 18 feet wide. The building is of Bedford, Indiana, limestone and reinforced concrete, and is essentially fireproof. The rear wing on the west is the Research Wing and has two floors. The other wing is for exhibits and has one floor. The front hall is for exhibits and has one floor. An unique feature of the two main exhibition halls is that they have no windows; the lighting is from skylights. The large front hall is devoted entirely to California mammals, and the rear exhibition hall to California birds.

In each of the exhibition halls the cases are built in against the wall. The regulation case for a large mammal or bird habitat group is 25 feet long, 12 feet deep and 18 feet high. Each case has a plate-glass front 15 feet long and 10 feet high. There are 11 of these large cases in the mammal hall and six in the bird hall. In the former are installed habitat groups of various species of large California mammals, and in the bird hall are similar habitat groups of California birds.

Among the groups alreads installed may be mentioned the Valley elk, black-tail deer (summer scene), mule deer (winter scene), antelope, desert mountain sheep, mountain lion, black bear, leopard seal, California sea lion, Steller's sea lion, coyote, Farallon Islands bird rookeries, San Joaquin water bird breeding grounds, desert bird group, California condor, and others. In each group the animals are placed in their natural environment, surrounded by the shrubs, trees, flowers, rocks and other objects such as make up a bit of the scenery which surrounds them in the region where they are found in nature. Then the real is extended by means of a curved painted background which connects so perfectly with the real objects in front as to make it difficult, if not impossible, to tell where the real ends and the painted begins. In addition to these large habitat groups similar small groups of smaller mammals and birds are being installed in suitable places at the ends of the large groups. These usually show a family of a single small species and the den and young if a mammal, and the nest, eggs or young if a bird.

One of the most serious problems in museum construction has been that of proper lighting. In most museums the visitor not only sees the animals in the case, but he sees himself there, and all the people about him, and all the other objects in that

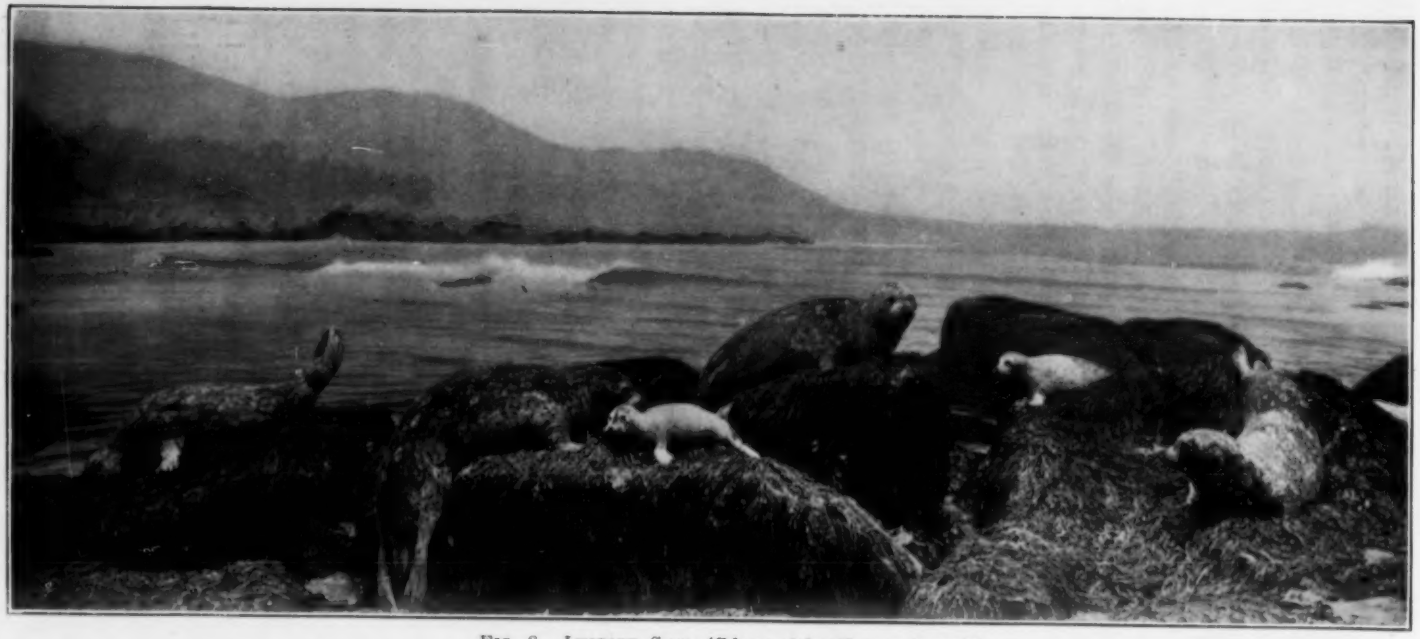

FIG. 8. LEOPARD SEAL (*Phoca richardi geronimensis*)

These interesting seals are fairly common in many places along the California coast, particularly in the bays. Unlike the fur seals which are highly polygamous, the harbor seals are monogamous. On the California coast the young are born in April and May; one pup is the rule. These seals are not migratory, nor are they as gregarious as other seals. They are comparatively silent, not making a loud roaring or barking as sea lions do. They are fond of basking in the sun, especially at low tide. On the land they are clumsy creatures. They move by pulling themselves forward by their foreflippers; in swimming the hind flippers do most of the work. The rookery here shown is at Cypress Point near Pacific Grove, California, where the animals were obtained. The background was painted by Charles Bradford Hudson.

part of the hall. The light *outside* the case is stronger than that *in* it, with the result that everything about the case is reflected in it, always confusing and sometimes quite obscuring the object one wishes to see. This difficulty, we think, has been almost entirely overcome and reflection into the cases practically eliminated by the system of lighting adopted by this museum. This system, as already mentioned, is by means of large skylights over each case and much smaller skylights over the middle of the hall where the observer stands, so small that they let in so little light that there is practically no reflection. Provision is made for artificial lighting at night and on dark days by means of electric lights with reflectors installed outside the cases and above the ceiling glass. There are also shades placed immediately under the skylights, by means of which the light can be modified as required.

The academy has been fortunate in being able to secure several of the best artists in America skilled in this kind of work to paint the backgrounds. One or more backgrounds have been painted by Charles Abel Corwin, of Chicago, Charles Bradford Hudson, of Pacific Grove, California, Maurice G. Logan, of Berkeley, and Worth Ryder, of Oakland. Mr. Corwin has probably had more experience in painting habitat group backgrounds than any other artist in this country. He has done a good deal of work of this kind for the Field Museum, and it was he who painted the really wonderful Laysan Island bird cyclorama for Dr. C. C. Nutting in the University of Iowa. Captain Hudson has also had considerable experience in this field. His backgrounds show an interpretation and finish which can hardly be excelled. But the work of all the artists is of the highest order of excellence. It is difficult, if not impossible, to see wherein any of the backgrounds could be improved.

All matters pertaining to the preparation and installation of the groups have been under the immediate direction of Mr. John Rowley, chief of exhibits. Mr. Rowley is a real artist in his line, remarkably resourceful in devising ways and means for accomplishing the best results. To Mr. Rowley must be given in large measure the credit for the wonderfully attractive and highly instructive habitat groups which are now to be found in the museum of the California Academy of Sciences.

In addition to habitat groups permanently installed in the museum, the academy has begun the preparation of small portable groups and exhibits to loan to the schools. These portable groups are in cases of convenient size and substantially made. The exhibit may be that of a species of bird, mammal, reptile or

FIG 9. CALIFORNIA SEA LION (*Zalophus californianus*)

This sea lion occurs on the sea coast and islands of California from San Francisco southward, breeding in many places, particularly on the Santa Barbara Islands. The rookery here shown is on Santa Cruz Island. Owing to their intelligence and small size this is the species of sea lion that is commonly trained and shown in zoological gardens and elsewhere. The males are darker in color than the females, and are sometimes called black seal lions. Another characteristic of the male of this species is the great development of the bony crest on the top of the skull. In early days sea lions were killed by thousands on the California coast for their hides and oil, but they have now become so reduced in numbers that sealing is no longer profitable. Sea lions as well as leopard seals are now protected on the California coast both by the state and federal governments. Among sealers the males are called "bulls," the females "cows," and the young "pups." The breeding season is from June to August, only during which time the males are found on the rookeries; at other times they go off in bands or singly living their lonely life. Background painted by Worth Ryder.

fish; it may be a group of butterflies or other insects; or it may be typical specimens of instructive minerals, fossils or plants. These exhibits are selected with the specific purpose of furnishing illustrative material for the nature work provided in the public schools. Each exhibit is accompanied by a simple explanatory label.

The museum also maintains a course of lectures throughout the year adapted to adults, and plans to conduct courses adapted to school children of the different grades, as already explained.

As I have already indicated, the educational function or duty is now the dominant influence in most of our American museums. Without curtailing in any way their activities in research work, they are making a special effort to be of real service in the educational field. The feeling among museum men may be expressed in this way: We have long had public schools and public libraries working to educate and train our people, why not public museums for the same purpose? And there are enthusiasts, men of vision, who believe the modern natural history museum will soon be so perfected in its equipment and methods that it will become the most potent force in giving to our children the education and the training that is most worth while.

We all well know how lamentably the public schools are failing to give the education and training they should give. We know how illy prepared our boys and girls are for the life they must live. We know that much which they get in the schools bears little or no relation to the life they are now living or that which they must live as men and women. We know that many of the subjects taught in the schools possess little or no educational value; that others which have value do not receive proper time allotments in the curriculum. For example, arithmetic in the grades receives 25 or 40 minutes per day for 8 years, while physiology and the care of one's health get but 15 minutes per week for a part of one year! It is even worse in the high schools. There the courses of study are devised in many schools to meet college entrance requirements. When we remember that 40 to 50 per cent. of the pupils who enter high school survive only one year or less, that only 3 or 4 per cent. ever go to college, it is evident that courses framed to meet college entrance requirements are meeting the needs of a *very small percentage* of the high-school pupils. It is not true, as we sometimes hear, that the course of high-school studies which best fits for college entrance requirements is the course which best fits for life. We must put it the other way and say that the studies which best

Worth Ryder.

FIG. 10. STELLER'S SEA LION (*Eumetopias stelleri*)

This magnificent animal ranges from the Santa Barbara Islands northward into Bering Sea. Formerly very abundant, persistent killing for its hides and oil has reduced its numbers greatly. Within the last few years they have entirely ceased breeding on the famous seal rocks near the Cliff House at the Golden Gate. A few individuals still resort to these rocks but they no longer breed there. These animals reach a large size. The adult bull shown in the group weighed 1,810 pounds. There is a great difference in size between the sexes, the females being not more than half as large as the males. Fishermen almost without exception claim that the sea lions are very destructive to the commercial fisheries. This is probably true at certain seasons and in some localities, but investigations have not fully sustained the charge. The breeding season of this species on the California coast is the latter half of June. One young is produced at a birth. The noise made by the Steller sea lion is a loud roar, resembling that of a real lion; this, together with the long yellowish hair of the necks of the bulls, doubtless leads to the name sea lion. This group shows the breeding rookeries on Año Nuevo Island just south of San Francisco. Background painted by Charles Abel Corwin.

fit the boy or girl for life are the studies which should best fit him for college should he go to college.

Domination of the high school by the college should stop; it should not be longer tolerated. There are too many subjects in the high-school courses, many of them put there specifically to meet absurd college entrance requirements, which bear no relation to what the average high-school student has ever done or ever will do. They possess no life value. They do not touch the life of to-day; they will not touch the life of the future.

Not long ago I visited a small village school. There I saw a class of country boys and girls, not one of whom is ever likely to go to college, or to be more than a laborer or mechanic or farmer in a small way; yet those poor children were being crucified on the Latin cross for 40 minutes every day. To the life they are living and the life they will live, Latin bears no relation; it does not touch their life anywhere. To them Latin is a subject *in vacuo*. In the high schools there are too many subjects of that kind, and much of the teaching I have seen is teaching *in vacuo*. Although the subject may be a proper one, as chemistry, history, geography or biology, it is often taught without relation to what the child already knows or the things with which he is concerned. Such teaching is "teaching *in vacuo*." The high-school pupil can often truthfully say of the subject and the laborious efforts of the teacher: "It never touched me." But poor teaching can be improved and made good, effective teaching; a useless subject, never.

That our schools are failing to give the education and training which fit for life is evident. The failure is, I believe, primarily due to the fact that the subjects taught are almost entirely memory subjects, or are so taught as to be little more than memory subjects. Little attention is paid to the training of the senses, or to acquiring skill of eye, ear or hand, or to acquiring those habits of accurate recording and cautious reasoning which modern science prescribes. The curriculum is made up largely of *faith subjects*—subjects which merely require the pupil to *believe* something that the text-book or the teacher says. No contact with real things; no training of the eye, hand or reasoning powers; no examination of facts or evidence; no reasoning and the forming of independent judgments; simply a memorizing of useless text-book statements. The facts or data upon which the judgment was based were examined by some one else, and the book and the teacher are like the keeper of a ready-made clothing store—they simply hand out to the pupil the ready-made judgment or conclusion and

FIG. 11. CALIFORNIA RACCOON AND STRIPED SKUNK

This raccoon is found throughout most parts of California, it being especially abundant in the heavily timbered country along the coast. The coon breeds in hollow trees, in holes in the rocks, in blind ditches, and even on the ground in tule swamps. Coons are omnivorous; they eat shellfish, frogs, fish and corn; they sometimes enter hen houses and kill and devour chickens. In the South the negroes are very fond of the raccoon, regarding its flesh as a delicacy. The raccoon ranks third in value among the fur bearers of California. The species of skunk shown in this group occurs throughout northern California except in the warmer interior valleys from Monterey northward. The skunk brings forth its young in holes in the ground, beneath buildings, in stone piles or in hollow logs. They feed largely on insects but will eat flesh of any kind, including chickens. As a fur bearer the skunk is among the most valuable in the United States. In some states skunk farming has become a profitable industry.

will not permit him to question it. Our schools are largely dealers in ready-made judgments and opinions; and nearly all second-hand goods at that.

The child is not taught or given an opportunity to examine the evidence for himself and to reach his own conclusion as to what the evidence shows. The book says it is thus and so, and he must not question the book. It is his duty only to read and believe. He must take on faith what the book and the teacher say. He is even disciplined if he asks any questions or manifests any doubt.

And what is the result? Almost invariably this: Any spirit of the investigator he may have had when he entered school is crushed out of him and he leaves school and goes through life taking things on faith. He becomes a blind follower. He accepts as true anything which he reads or is told by any one in whom he has faith. He never asks to see the evidence; he never reasons; he never forms his own judgments. He can not distinguish fact from fancy, reality from fraud. He falls a ready prey to any fallacy or fraud that comes along, however bald it may be; and the more absurd and bald it is the better he seems to like it.

Of course, I do not mean to say that *all* who go through the public schools are such "easy marks" for the army of frauds and shysters—political, religious, economic, health, and a host of others that infest our land, but it is only necessary to call attention to the thousands who are believers in Ralston Health Clubs, double standards, faith cures, and a score of other frauds and fallacies which flourish in this land, to show that they constitute a very large part of our population. America is said to be the home of shysters and quacks; and the public schools are largely responsible. The remedy lies in radical changes in the courses of study and the method of instruction.

It has been shown that the secondary schools give not more than one tenth to one sixth of their time to observational, sense-training subjects. It is almost equally bad in the primary schools. I wish to quote President Eliot in this connection. He says:

> The changes which ought to be made immediately in the programs of American secondary schools, in order to correct the glaring deficiencies of the present programs, are chiefly: the introduction of more hand, ear and eye work—such as drawing, carpentry, turning, music, sewing, cooking, and the giving of much more time to the sciences of observation—chemistry, physics, biology and geography—not political, but geological and ethnographical geography. These sciences should be taught in the most concrete manner possible—that is, in laboratories with ample experimenting

FIG. 12. CALIFORNIA COYOTE

There are several species of coyotes. The one here shown (*Canis ochropus*) is quite common in the San Francisco bay region. The coyote, wherever found, is a cunning, sneaking rascal, very destructive to ground-nesting birds, rabbits, sheep, pigs and poultry, usually nocturnal and predatory in its habits; nevertheless, an interesting animal which easily gains our admiration because of its sagacity. In most states a bounty is offered for its capture. Background by Maurice G. Logan.

done by the individual pupil with his own eyes and hands, and in the field through the pupil's own observation guided by expert leaders.

And here is where the modern natural history museum finds its place as a factor in public education. The modern museum is in fact many laboratories in one. It is as nearly the fields, hills and all out doors as it is possible to make it within doors. The real objects are there in their natural environment and proper relations. They furnish the materials for observation, comparison, study and the forming of judgments. And they make it easy for the teachers to improve their methods of teaching, to teach concretely.

Indeed, they contain the necessary materials for practically all the teaching that need be done in the elementary and secondary schools. They contain and can supply materials not only for all the observational studies, but most of the other subjects, as arithmetic, language, geography, reading, writing, spelling and even morals. All these subjects become concrete, live subjects when related to real things.

Number work and all the fundamental processes of arithmetic, as addition, subtraction, multiplication, and division, become concrete and easily taught and understood when taught with real objects as illustrative material. The same is equally true of geography, many of the principles and important facts of which can be taught as a part of the study of the museum specimens. And no better drill in language and composition is possible than can be had in connection with the study of real things. In asking and answering questions about them and talking about them, excellent drill in spoken language is had; in writing questions and answers and in preparing descriptions and formal compositions about them, the very best of exercise and drill in language, composition, writing and spelling, is afforded. And drill in oral reading and clearness of expression comes with the reading by the pupils of the compositions and statements they have written.

When a pupil writes a composition on some material object that is put into his hands, some object that he has seen and handled and studied, he writes what he himself knows, he gives expression to that which he himself has experienced. It is knowledge, not mere information. He is dealing with realities, with truth, not with imagination.

And such exercises and studies as these are the very best possible to develop character. To realize the stability of truth, to realize that unchanging, immutable law pervades the universe, that everything is subject to law, that ignoring or violat-

FIG. 13. FARALLON ISLANDS BIRD ROOKERY

In this group, presented to the California Academy of Sciences by the Hon. Wm. H. Crocker, are shown the ten species of sea birds and the one land bird (the little rock wren) that breed on the Farallon Islands. These rocky islands are about 30 miles off the Golden Gate, from which they may be seen on any clear day. Thousands of sea birds resort to these cliffs to lay their eggs and rear their young, one of the most common species being the western gull which, during the rest of the year, is very abundant about San Francisco, following the ferry boats across the bay. Until a few years ago thousands of Murre's eggs were brought each year from these rookeries and sold in San Francisco to the bakeries and pastry shops. The islands are now a federal reservation and the birds and their eggs are rigidly protected. Background painted by Maurice G. Logan.

ing law leads to disaster—all this develops stability of character. They are conditions of mind which cause respect for law and truth and order and honesty, and they develop those traits of character.

And now in conclusion permit me to say a word regarding one more of the interesting and important recent developments in museum activity, namely, the Children's Museum or the Children's Room. This is clearly one of the results of the growing conviction that the museum is a public educational institution which should meet the needs of all ages and classes of people. While many of the public museums of America have realized

this need and have been trying more or less successfully to meet it, the institution which has been most successful in this very important field is undoubtedly the Children's Museum of the Brooklyn Institute of Arts and Sciences.

Under the able direction of Miss Anna Gallup really wonderful results have been attained. Children are naturally interested in animals and plants, the material things about them, and the forces and phenomena of nature. As President Eliot has so well said:[2]

> The best part of all human knowledge has come by exact and studied observation made through the senses of sight, hearing, taste, smell and touch. The most important part of education has always been the training of the senses through which that best part of knowledge comes. This training has two precious results in the individual besides the faculty of accurate observation—one, the acquisition of some sort of skill, the other the habit of careful reflection and measured reasoning which results in precise statement and record.
>
> A baby spends all its waking time in learning to use its senses, and to reason correctly from the evidence of its senses. At first it reaches after objects near by and far off alike, but gradually learns to judge by the eye whether or not it can reach the object seen. It tries to put everything into its mouth, perhaps in an effort to estimate size and shape correctly—which at first it can not accomplish by the eye alone, as the adult does. . . . The baby's assiduity in observation and experimentation, and the rapidity of its progress in sense-training are probably never matched in after-life. Its mind also is trained fast; because it is constantly practising the mental interpretation of the phenomena which its senses present to it.

The child undoubtedly acquires more real knowledge during the first five or six years of its life, before it ever enters the formal schools, than it does in all the after years.

The boy on the farm has admirable opportunities to train eye and ear and hand; because he can always be looking at the sky and the soils; the woods, the crops, and the forests; the streams and the hills; he daily, even hourly, sees the wild animals, the birds, the mammals, the insects, that usually abound about him; the domestic animals on the farm he learns to know most intimately; he learns to use various tools, he hears the innumerable sweet sounds which wind, water, birds and insects make on the countryside, and when he is hunting, fishing or merely roaming in the woods and fields and along the streams.

All this is education of the right sort—which is rarely or never equalled in the schools—because it is all most intimate personal experience, the only way in which actual knowledge can be acquired.

That this natural method—the only method by which knowl-

[2] Changes Needed in American Secondary Education."

FIG. 14. SAN JOAQUIN VALLEY BIRD GROUP

Presented to the Museum of the California Academy of Sciences by Hon. Joseph D. Grant. In the spring and early summer it is the practise of the cattlemen of the San Joaquin Valley to flood their land with water, to a depth of 6 to 18 inches, to induce a ranker growth of grass for pasture. Many thousand acres are thus flooded and converted into marsh land, to which vast numbers of ducks, waders and other swamp-loving birds are attracted. During the breeding season great numbers of birds resort there to build their nests, lay their eggs, and rear their young. These breeding grounds are frequented by more than 30 species of birds. Among those shown in this group, which shows a typical breeding ground near Los Baños, Merced County, California, are the fulvous tree duck, cinnamon teal, shoveler, red-headed duck, coot, American bittern, least bittern, glossy ibis, avocet, black-necked stilt, killdeer, red-winged blackbird, yellow-headed blackbird, tule wren, little black tern, Forster's tern, and the Virginia rail. In order to show in a limited area a considerable number of species it was necessary to bunch the birds a little more closely than they actually occur in nature. The background was painted by Maurice G. Logan.

edge can be acquired—should be so largely, almost wholly, abandoned when the child enters the schools, is hard to understand, but it is lamentably true. The schools, instead of continuing the methods and processes by which knowledge is gained, almost without exception subject the child to processes and methods which result merely in the acquiring of information, most of which is of little or no value in the development of character or in fitting the child to live the life he must live.

The Children's Museum is different from the conventional public school. Its method is that with which the children are very familiar before they ever enter a public school—the method by which knowledge is acquired. The Children's Museum continues this method. The children, even into and through their teens, continue to deal with realities; they continue to use their eyes and ears and organs of taste and smell and touch, for the museum is simply certain parts of nature, of outdoors, brought indoors for examination and study; all selected with reference to their educational value. The imparting of information, or mere book information, has no place, or, at most, a very subordinate place, in a museum.

Unfortunately, the schools, which might have continued this natural method, have for the most part clung to the traditional programs which rely chiefly on studies which train the memory, but which "do not train or drill children in seeing and hearing correctly, in touching deftly and rapidly, and in drawing the right inferences from the testimony of their senses."

A well-appointed children's museum or children's room will have in it those natural objects which have always interested children everywhere. There will be brightly and curiously colored birds and butterflies, moths and beetles, and other insects, curious animals of other groups, attractive minerals, growing plants, and aquariums with interesting animal and plant life; colored transparencies of beautiful flowers, all selected and arranged with reference to the telling of an interesting story, the teaching of a definite lesson.

And there will be in this children's museum simple tools and machinery for training the hand and eye, laboratories where the little girls can learn to do by doing and where they can, through practise, become familiar with many of the simple principles of domestic science and art; and others where the boys can become familiar with the simple tools and machines and become proficient in their use. There is no limit beyond which this training of the hand and eye may not be carried. As an illustration, in the Children's Museum in Brooklyn, a

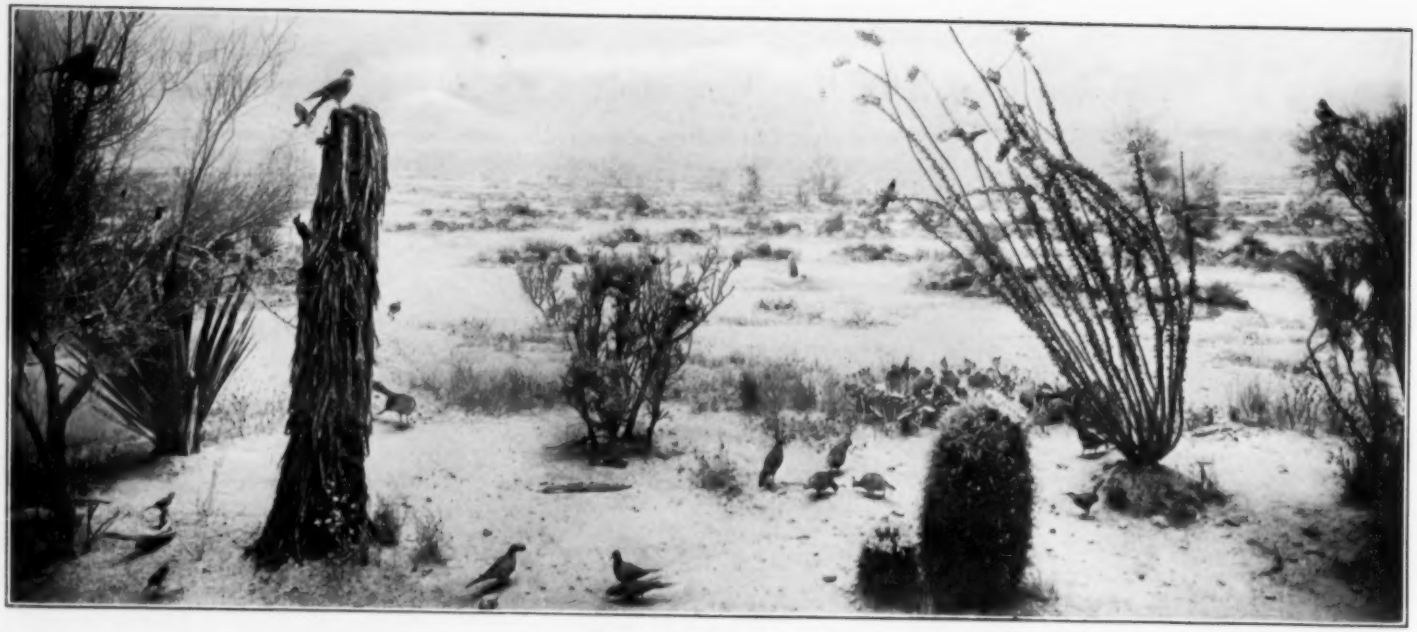

FIG. 15. DESERT BIRD GROUP

In this group, presented to the California Academy of Sciences by Hon. Wm. B. Bourn, are shown, under natural surroundings, several species of the birds that nest in the Colorado and Mohave deserts of southern California. The particular locality represented is in Riverside County, California. The spring rains transform the desert into a veritable flower garden, the many and varied forms of vegetation sending forth an astonishing amount of beautiful bloom. Then is the nesting time of the birds, which are there in surprising numbers, some of them, as the hooded oriole and the vermilion flycatcher, rivaling the flowers in brilliancy of coloration. The total number of species of birds nesting in this part of the Colorado desert is more than a score, and some species, as Gambel's quail, are very abundant. The nests, however, are usually widely scattered except in the vicinity of water. Background painted by Charles Bradford Hudson.

special feature has been made of wireless telegraphy, and a number of boys who got their training in that museum are now occupying responsible positions in charge of wireless plants or as skilled operators in various parts of the world.

It is of vital importance that the right sort of person be placed in immediate charge of the children's museum or children's room; a well-educated, kindly, sympathetic woman or man who knows the specimens in the museum and the live things in the park or fields or woods about it; and who, above all, knows and loves children; one who can wisely direct the observation and the reading of the children so that they may correlate their reading with what they have seen in the museum or the open, and thus increase rather than stifle their love for animate things, as our public schools almost invariably do. In such a museum it will be arranged so that the children of the different grades will come to the room at different hours and receive in turn the instruction and help adapted to their respective needs.

There is no better thing which any city, town or village can do than to establish and maintain a museum of this kind. In some form or another it is already being done by the Children's Museum of Brooklyn, also by the American Museum of Natural History in New York, the Charleston Museum, the Milwaukee Public Museum, the Chicago Academy of Sciences, and elsewhere. The time is not far distant, I verily believe, when the same will be done in many other cities and towns. It will be done because it so evidently appeals to us all as the *right thing to do*, the right sort of education and training to give to our children. It will be done, because the beauty of it all, for the little children's sake, will appeal to those who have prospered in this world; those with kindly hearts, who love children, and who want them to become the men and women they should become; and the time is now ripe for these good men and women who are able to do so to come forward, and out of their abundance do this splendid work not only for the children of to-day but for those of the years to come.

Habitat Groups in the Museum of the California Academy of Sciences

The California Academy of Sciences has recently installed in its new museum in Golden Gate Park a large number of habitat groups of important species of California mammals and birds, one large hall being devoted to mammals, and another to birds.

The central, controlling thought with these groups has been to make them as true to life as possible and of the highest educational value. To accomplish this object the taxidermist who was directly responsible for the group went to the locality where the animals were secured and studied the local environment, collecting specimens of the shrubs, grasses, flowers, rocks, etc., found there. With these, properly preserved, and with artificial flowers, etc., when necessary, he was able to reproduce the actual environment with great fidelity.

In each group is a curved painted background connecting so perfectly with the actual objects in front that it is difficult, if not impossible, to tell where the real ends and the painted begins.

In every case the artist visited the region where the animals were taken, studied the scenery, made his field sketches and studies, and when he made his final painting he was able to give what is in effect a painting of a real scene somewhere in the region where the species is naturally found.

THE SCIENTIFIC MONTHLY is able to reproduce photographic illustrations of a number of these groups. The groups were installed under the general supervision of Dr. Barton Warren Evermann, the director of the museum, the mammal groups under the immediate direction of Mr. John Rowley, assisted by Mr. Joseph P. Herring and Mrs. M. L. Pariser. The bird groups were prepared under the immediate direction of Mr. Paul J. Fair, assisted by Mrs. M. L. Pariser.

The backgrounds were painted by Charles Abel Corwin, of Chicago, Charles Bradford Hudson, of Pacific Grove, California, Maurice G. Logan, of San Francisco, and Worth Ryder, of Oakland, all well-known artists. Each of these artists has been marvelously successful in depicting the natural environment of the animals with which he had to deal.

POTHOLES: THEIR VARIETY, ORIGIN AND SIGNIFICANCE. II.

By E. D. ELSTON

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Initiation and Development of Normal Potholes

IT is evident from the classification given above that all varieties of pothole depressions have a turning or vortex flow of water (provided with sediment tools) as at least a contributing factor in their formation. Accordingly, it would seem that an investigation of the exact conditions of the initiation and development of the normal type of pothole would furnish the most significant data in regard to the origin of these depressions in general, and also furnish some measure of their function in the process of gorge cutting by young streams. Some results of such a study and deductions based on actual observations with particular reference to occurrences in horizontally bedded sandstones and shales follow.

Ideal Normal Potholes.—Normal potholes are developed by the rotary grinding motion imparted to rock tools—sand, pebbles, boulders—in a depression of the bed of a stream course by the water current. A typical normal pothole should have the following characteristics: At the top the hole should be almost circular in ground plan, with a diameter ranging from three inches to ten feet or more. The depth might vary between six inches and eight feet or more. In vertical section an ideal normal pothole should show the same outline as that of a similar section through one of the old-fashioned iron pots that have wide curved mouths and bulging sides (see Fig. 8). No doubt normal potholes owe their name to this resemblance. There are, however, many deviations from this perfect form. The holes show much irregularity in ground plan as well as lack of symmetry in the bulging of the sides. Very commonly the smooth inside surfaces of the excavations are interrupted by ridges or flutings. Other typical examples of normal potholes are shown in Figs. 9*a*, 9*b*, 10. The kinds of material that may be found in the potholes are of interesting variety. Usually masses of rubbish consisting primarily of sand, gravel,

pebbles and boulders and perhaps fragments of other materials are found in holes either temporarily or permanently abandoned by the stream. Some of the pebbles or boulders may be smoothed and rounded, due to the grinding action. In describing the material taken from some potholes in Norway, Brögger and Reusch[25] state that two types of grinding stones may be distinguished: (1) Perfect or regularly elliptical; (2) less per-

Photo by J. S. Hook.

FIG. 8. SECTION OF NORMAL POTHOLE, showing similarity in shape to old-fashioned iron pot. Note ridges or flutings on interior surface.

fect with elliptical tendency. According to these writers the perfect type of grinding stones become more numerous near the bottom of the hole. The grinding stones are usually of the harder, more resistant kinds of rock such as sandstone, quartzite, etc. Due to their almost spherical or elliptical form the grinding stones often attract much attention and in not a few cases such beautifully rounded stones have been gathered as curiosities or for use in rockeries.

[25] Brögger, W. C., and Reusch, H. H., "Giants' Kettles at Christiania," *Quart. Jour. Geol. Soc. of London*, Vol. 30, pp. 754–761, 1874.

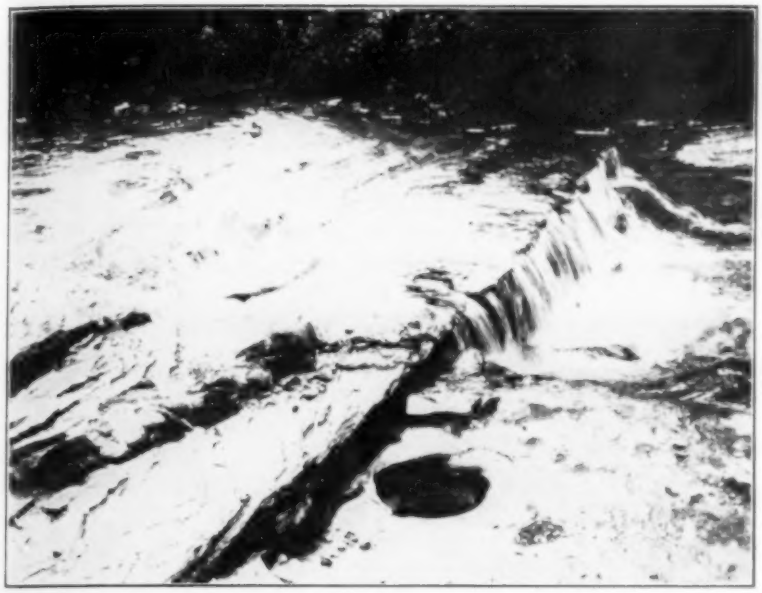

FIG. 9A. NORMAL POTHOLE IN UPPER GORGE OF CASCADILLA CREEK, ITHACA, N. Y.

During periods of high water, sand, gravel and boulders are swirled by the current and become very effective as abrasive agents both in smoothing, rounding out and enlarging the hole and also in reducing to finer fragments the tools themselves by rubbing them against each other and rounding the pebbles.

FIG. 9B. VIEW OF INTERIOR OF POTHOLE SHOWN IN FIG. 9*a*. Note small pits at right in bottom of the hole. These pits are due to railroad spikes caught in the pothole and then hammered repeatedly against the sides by the water current and fragments of rock.

When the erosive action ceases the holes are choked with this detritus, the greater part of which is sand and silt. In some cases, however, much of the material is rock fragments of the size of gravel or even of larger pebbles. The material in an abandoned pothole very commonly is packed in so closely that much effort is required to pry out the fragments. A pothole in the Ithaca region, so packed, contained, in addition to a considerable amount of sand and gravel, several railroad spikes which had been used as tools in the excavating process

FIG. 10. ANOTHER NORMAL POTHOLE IN UPPER GORGE OF CASCADILLA CREEK, ITHACA, N. Y. Note the two rounded grinding stones removed from the hole.

for the points of the spikes had been firmly driven and wedged into niches in the bedrock (see Fig. 9).

Structural Phenomena of Bed Rock Leading to the Initiation of Normal Potholes.—It is immediately apparent that the primary factor in the initiation of a normal pothole development is the presence of some condition of the bedrock channel over which the stream flows that will give a rotary motion to the water. Evidently the chief, and perhaps the only condition that brings this about is the occurrence of some structural irregularity that leads to the development of a shallow depression in the stream course. The possibilities of this kind are quite numerous. There may be mentioned, *irregularity in*

bedding, ripple marks, lenticular concretionary structure, solution irregularities, and joint planes.

Irregularity in bedding is of very common occurrence in stratified rocks and is well illustrated by Fig. 11. The rock surface, developed along stratification planes, is often very irregular and this condition frequently extends into the structure of the underlying material. As the stream erodes the general area of its channel bottom the tendency is to flake off such bedrock in accordance with its structural undulations. Thus a

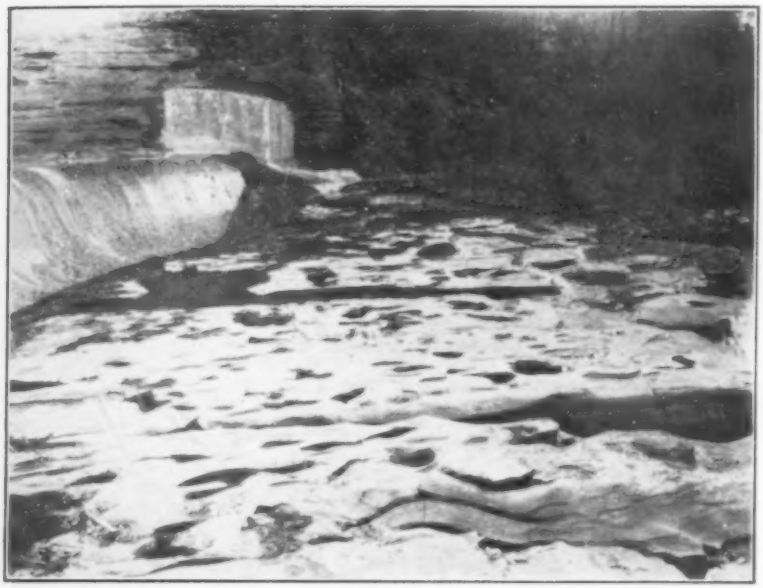

FIG. 11. IRREGULARITY IN BEDDING OCCURRING IN SIX MILE CREEK VALLEY, ITHACA, N. Y.

hummocky surface is created and in the shallow depressions between the knobs sediment tends to collect.

Ripple marks are familiar features in stratified rocks. Variations in their development are shown in Figs. 12 and 13. The troughs between the crests afford a favorable place for sediment to lodge.

Another special case of irregularity is due to what may be termed "*lenticular concretionary structure.*" This is found where beds containing concretions have been bowed up over the concretions and caused to sag beneath them, as is apparent in Fig. 14. No potholes have been observed in such a formation

FIG. 12. RIPPLE MARKS IN SHALES IN BED OF FALL CREEK NEAR SIBLEY COLLEGE, ITHACA, N. Y.

FIG. 13. POTHOLE IN SHALE. Surface shows rather irregular ripple marks, located near area shown in Fig. 12.

by the writer, but it is quite possible that such structure may cause the initiation of potholes in a manner somewhat similar to that in which it caused the initiation of Tide Pools as de-

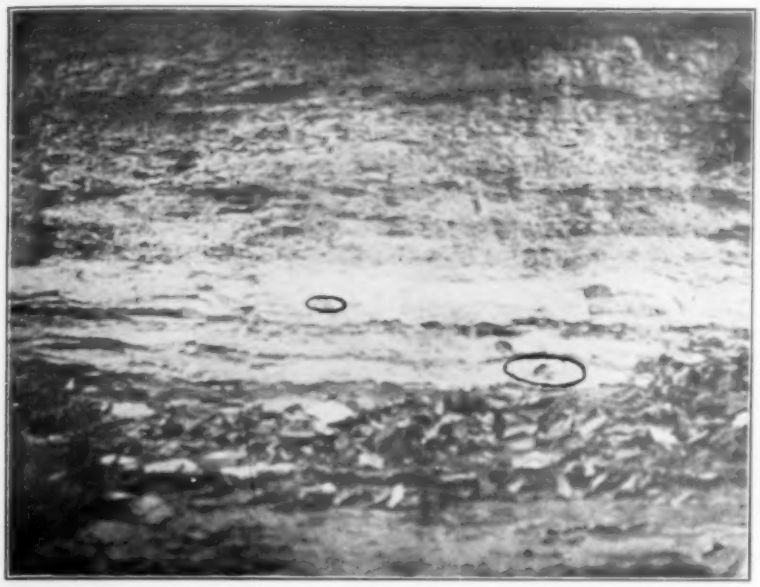

FIG. 14. LENTICULAR CONCRETIONARY STRUCTURE IN UPPER GORGE OF BUTTERMILK CREEK, NEAR ITHACA, N. Y.

scribed by Henkel.[26] If one of the concretions should be removed by stream grinding it would leave a shallow depression

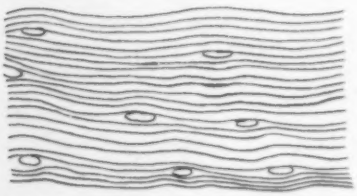

FIG. 15. LENTICULAR CONCRETIONARY STRUCTURE.

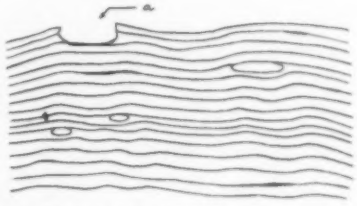

FIG. 16. DEPRESSION FORMED BY THE REMOVAL OF A CONCRETION.

that would act as a catch-all for the rock tools of the stream and a pothole might eventually develop. See Figs. 15 and 16.

Solution Irregularities.—These slight irregularities, illustrated by Fig. 17, are due primarily to the solvent action of the

[26] Henkel, Isabel, "A Study of Tide Pools on the West Coast of Vancouver Island." *Postelsia*—The Year Book of the Minnesota Seaside Station for 1906, pp. 298–303.

water and are especially common in limestone rocks and are often associated with potholes.

FIG. 17. SOLUTION IRREGULARITIES IN LIMESTONE, TAUGHANNOCK CREEK, NEAR ITHACA, N. Y.

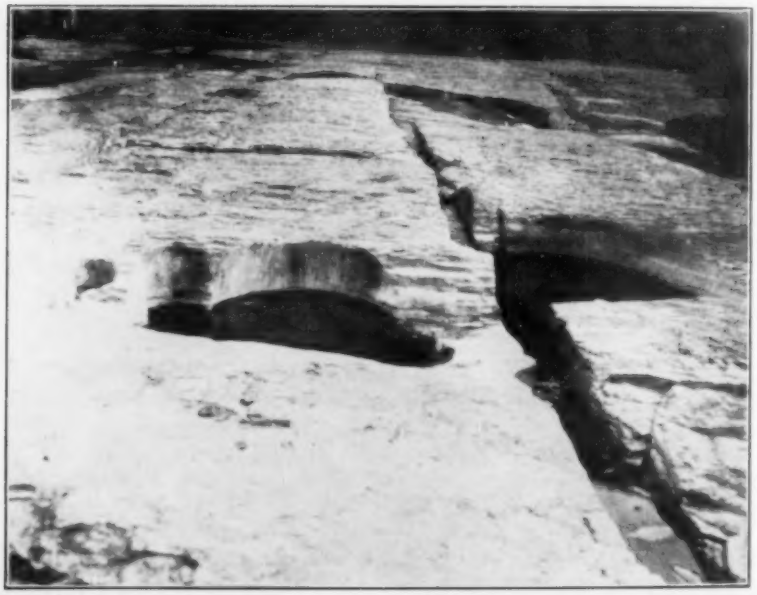

FIG. 18. JOINT PLANES WIDENED OUT BY EROSION AND POTHOLES OCCURRING ALONG THE JOINT PLANES, FALL CREEK, ITHACA, N. Y.

Joint planes seem to be the most important single factor in causing the initiation of the normal potholes. Along a single joint plane the rock is less resistant at some points than others.

This is notably the case in shales, where fragments may often be more readily detached in certain spots adjacent to the joint crevices than elsewhere. The resulting depression, if it is in the course of an eroding stream, frequently becomes enlarged. Again, at the point of intersection of planes, the corners of the rock are readily chipped away by boulders striking against them or such corners may be worn away by the combined processes of stream grinding (corrasion) and solution (corrosion). If the bed rock at the place of such intersection of joint planes is submerged only a part of the time and exposed during periods of low water, it is possible that weathering will

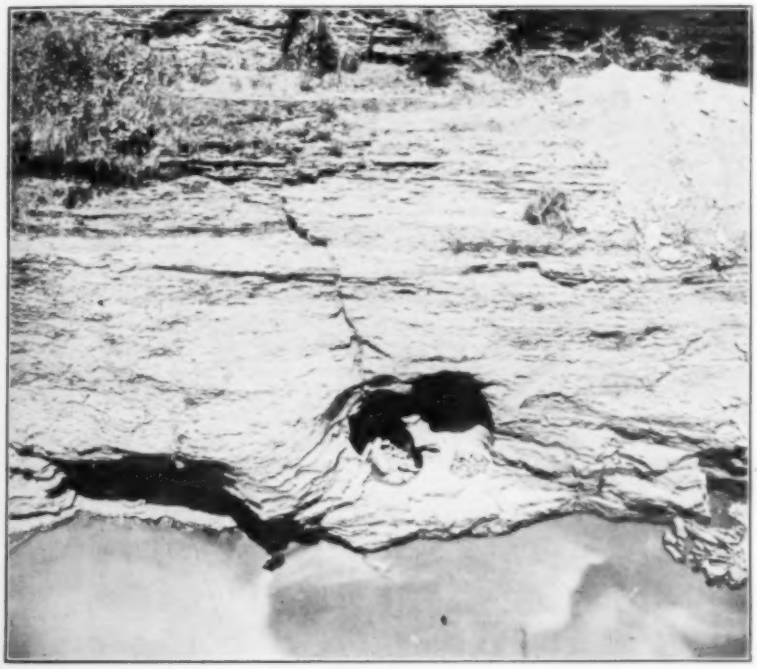

FIG. 19. POTHOLES DEVELOPED ALONG A JOINT PLANE, FALL CREEK, ITHACA, N. Y.

also aid in enlarging the depression. Such hollows apparently afford most excellent sites for the development of potholes (see Figs. 18, 19 and 20).

Joint planes, in addition to occasioning hollows at which potholes may start, may also influence the later development of the holes. The joints do not always extend vertically into the rocks. Sometimes they are inclined away from the perpendicular, or in geological terms, have a considerable *hade*. Assume, as shown in Fig. 21, that the joint plane extends vertically into

the rock mass, *i. e.*, that the hade is 0°. If this joint plane cuts the edge of the hole or occurs near the hole, the line of weakness will be continued straight down and in accordance with these conditions, the pothole should theoretically be excavated vertically into the bedrock.

If, on the other hand (see Fig. 22), the joint plane has a large hade, the hole should, if our theory is correct, extend into the rock at an angle approximately equal to the hade, provided

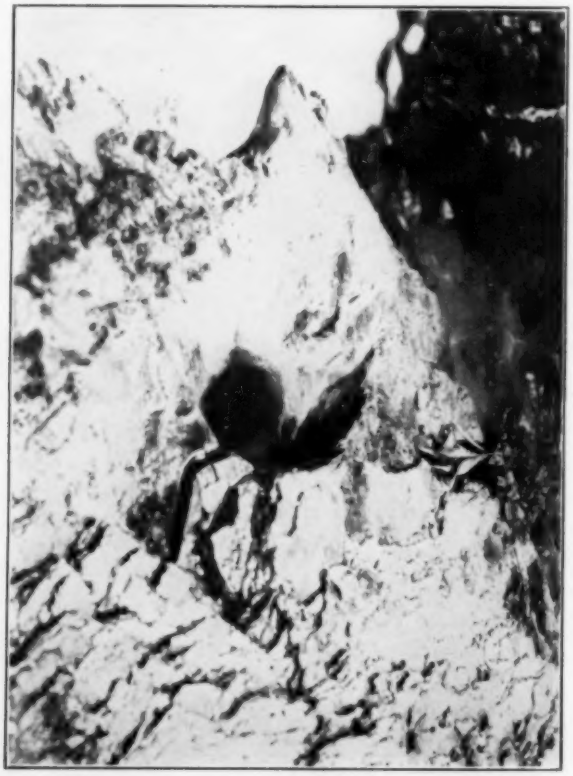

FIG. 20. POTHOLE OCCURRING NEAR INTERSECTION OF JOINT PLANES, CASCADILLA CREEK, ITHACA, N. Y.

that the joint plane does form a line of weakness along which the effectiveness of erosion is concentrated. While no examples have been observed by the writer, where it was certain that such was the case, in several instances it seemed quite possible that hading of a joint plane had been a factor.

Potholes Inherited from Preexisting Conditions.—As will be noted from the foregoing discussion, it is easy to conceive of various structural variations in the bedrock of stream courses,

that might cause the initiation of potholes and influence their later development. To deduce on theoretic grounds the probable effect of these structural phenomena is not difficult. Yet, after examining many holes, it became apparent that the connection between their occurrence and such structural features was by no means so obvious as would at first seem probable. Particularly is this true of many of the larger, more typical, well-developed holes. Even when a detailed search was made it proved difficult to find single examples where incontestable correlations could be made between initiating cause and the occurrence.

There is obviously a connection between waterfalls and plunge pools. Furthermore, there is every gradation between plunge pools and normal potholes. The latter often mark the site of waterfalls the crest of which has since receded. Such potholes usually occur in a series leading up to the site of present active development. Excluding these, there still remain a number of potholes, the occurrence of which does not present

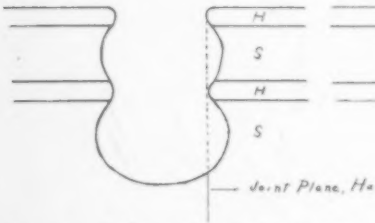

FIG. 21. INFLUENCE OF JOINT PLANE HADE ON DEVELOPMENT OF POTHOLE. Resistant and less resistant layers marked H and S, respectively.

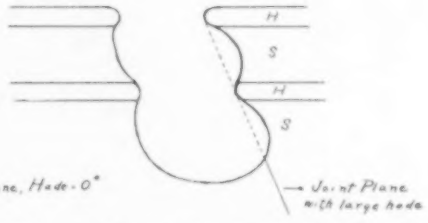

FIG. 22. INFLUENCE OF JOINT PLANE HADE ON DEVELOPMENT OF POTHOLE. Resistant and less resistant layers marked H and S, respectively.

evidence of formation by waterfalls and yet they seem unrelated to existing structural conditions. Perhaps no single one of a number of such holes will show any distinct relation to an initiating cause or reason for development at just that point. What then is the cause of these potholes? Why are they found at such places where no relation seems to exist between them and the structural phenomena present?

It would seem that most normal potholes owe their existence to initiating causes that have disappeared since the formation of the holes. Accordingly it is proposed to describe them as *potholes inherited from preexisting conditions.*

The case may be especially well illustrated in connection with joint planes. Some of the joints are strong in sandstone

and notably weak in underlying shales, according to Sheldon.[27] Assume that at an earlier stage in the downcutting by the stream a pothole was initiated in the sandstone layer due to the intersection of joint planes which were strong in the sandstone but weak in the shales beneath. Assume further that this hole attained a considerable depth and development and that its lower portion was cut into the shales in which the initiating joint planes did not continue. In time the stream erosion wore away the sandstone layer. The pothole, however, continued to be eroded in the shales. Once started, the swirl of the water

FIG. 23. SCALLOPED CHANNEL DUE TO POTHOLE ACTION IN WATKINS GLEN, N. Y.

currents continued to be effective and the hole was deepened at a rate commensurate or surpassing that of the general erosion of the stream bed. Thus it remained a feature of the stream course when the bed of the stream has been cut below the layer in which the hole was originally started.

Not only does this development history seem probable where the weak spots are caused by joint planes in the upper layers, but it also seems just as likely to occur if any one of the other structural weaknesses previously described occurs in layers later removed.

[27] Sheldon, P. G., "Some Observations and Experiments on Joint Planes," *Jour of Geol.*, Vol. XX., No. 1, January–February, 1912, pp. 64, 65.

Henkel[28] observed in the case of tide-pools along the west coast of Vancouver Island, that some of the depressions were cut so that their bottom portions existed in sandstone and their top portions were in conglomerate, only a portion of the latter remaining due to erosion. Apparently this is an excellent example of inheritance from preexisting conditions.

The general theory, then, of inherited potholes accounts very satisfactorily for the development of large and small holes situated near each other in a rock surface which is apparently homogeneous throughout. The smaller holes are the most recently formed. They may in the future be extended downward into the underlying material. The material which is now at the surface may later be worn away and the potholes still continue their downward development (provided that conditions of erosion are maintained).

Irregularities of the Interiors of Potholes.—Where strata of unequal resistance to the grinding process of pothole formation occur within the depth of a single hole, the interior is commonly fluted, the resistant layer projecting beyond the weaker layers above and below. Possibly such fluting in some cases is due to variations in the erosive effectiveness of the currents moving in the hole, due to variations in the stream volume and its sediment load.

No conclusive determination of the exact conditions that lead to the progressive enlargement of the diameter of a pothole below the surface has been made. Brunhes and Brunhes[29] assert that centrifugal force causes the velocity of the water to increase at the sides of the hole, hence the tendency toward undercutting. There must also be a certain limiting depth to which a pothole can be excavated by a current of given volume and velocity provided with an optimum of rock tools. The variable factors, however, are so many that it would be difficult to establish any definite relations of this kind.

Pothole Development and Gorge Cutting.—It has been previously suggested that pothole development is a significant if not a primary process in the early stages of gorge cutting by

[28] Henkel, Isabel, "A Study of Tide-Pools on the West Coast of Vancouver Island," *Postelsia*—The Year Book of the Minnesota Seaside Station for 1906, p. 293.

[29] Brunhes, B., and Brunhes, J., "Les Analogies des Tourbillons Atmospheriques et des Tourbillons des Cours d'Eau et la Question de la deviation des rivières vers la droite," *Anales de Geog.*, Vol. 13, 1904, pp. 1–20.

streams. Fig. 2 illustrates this relation very clearly. Cleland[30] cites another instance of even more striking character. He describes a natural bridge formed in impure limestone over the Kicking Horse River, near Field, B. C., by the lateral enlargement and intersection below the surface of adjacent potholes. Some idea of the proportions of this feature may be gained by the figures he gives. The bridge averages ten feet in width, has a span of about eight feet and the arch is six to eight feet thick.

Watkins Glen, a quite famous gorge in central New York, owes much of its picturesqueness to the fact that its bottom course is almost exclusively the result of pothole erosion. The stream flows from one pothole to the next, forming the scalloped channel border illustrated by Fig. 23 as a result. Above, the gorge has been widened by weathering, but there is hardly any question but that these strata were also originally cut through by pothole grinding. In order to determine the rate at which potholes are enlarged, a plaster cast was made of a typical occurrence near Ithaca, N. Y., in the summer of 1914. Some time in the near future it is proposed to make another cast of the same hole and measure the volume of rock material that has been removed. At the same time it may be possible to determine how much the general level of the bed of the stream has been worn down. In this way it is hoped to obtain a suggestion of the quantitative relations of general and pothole deepening of stream channels. It would be interesting to have similar measurements made by observers in other localities as a comparison of results under different conditions would afford a basis for a general deduction of the effectiveness of the pothole grinding process in deepening stream valleys.

SUMMARY

1. Potholes develop only in streams that are actively eroding in fairly well consolidated rock.

2. An initial hollow in the bedrock is necessary to permit of the primary collection of the sediment and stones that are to be the tools with which the pothole is ground out.

3. The stream must carry at least a *moderate* amount of material to be used as grinding tools. Streams heavily laden with sediment tend to deposit rather than erode and too much material chokes the initial depressions.

[30] Cleland, H. F., "North American Natural Bridges," *Bull. Geol. Soc. of America*, Vol. 21, 1910, pp. 321–322.

4. The initial hollow may be originated by any one of the following factors: irregularity in bedding; ripple marks; lenticular concretionary structure; solution irregularities; joint planes.

5. The inception of a given pothole may be due to one or more of these structural weaknesses.

6. The larger holes seem almost invariably to be *inherited from preexisting conditions.*

7. The later development of a hole is influenced by the following factors, among others: the volume and velocity of the stream; the direction of currents; nature, structure and position of the rock, the hade of joint planes; union of two or more holes.

8. Most of the erosion of the holes is apparently accomplished during flood stages.

THE INFLUENCE OF MAGNETISM ON LIGHT

By Professor L. R. INGERSOLL

UNIVERSITY OF WISCONSIN

IT is not such a great while since the various subjects of light, heat, electricity and magnetism, embodied in the science of physics—or "natural philosophy" as it used to be called—were thought of as discrete branches only slightly interrelated. The task of showing the connection between them may be thought of as commenced by Oersted, who discovered, almost exactly a century ago, the effect of an electric current on a magnetic needle. Half a century later the theoretical work of Maxwell supplemented by the experiments of Hertz showed that light is, fundamentally, nothing but a particular manifestation of electrical and magnetic phenomena. But the discovery of the electron in recent times has done more than anything else to unify physics, and the division of the science into branches may be regarded henceforth merely as a separation for convenience in instruction rather than as a natural cleavage.

But while light is now well known to be an electromagnetic wave phenomenon, occupying indeed a position intermediate between the long electromagnetic vibrations or wireless waves, on the one hand, and the extremely short undulations which the X-rays have very recently been shown to be, on the other, the experimental study of the relationship is not simple. Nevertheless a whole series of investigations, initiated by Faraday's capital discovery of the rotation of the plane of polarization produced by a magnetic field, has been carried out in recent years with the aim of finding out the effect of magnetic and electrical influences on light.

The most striking result yielded so far is the effect, discovered in 1896 by Zeeman, of a powerful magnetic field on a source of light. This phenomenon, which is too minute to have been observed by Faraday, who tried the experiment, consists, in its simplest form, of the doubling or tripling of a spectral line according as the source is observed along the line of the magnetic field, or across it, respectively. On the basis of the electron theory the explanation may be outlined as follows: Suppose that in a small monochromatic source of light (*e. g.*, vacuum tube, flame, etc.) between the poles of a large electro-

magnet one of the countless electrons is rotating in a circular path about the axis of the field, giving rise as it does so to a light wave of period corresponding to its rotation. If, now, the magnet is excited there will be a force acting on this electron—just as there would be on a flexible circular wire carrying a current—which will tend to pull it into an orbit of smaller radius or push it out to a larger one according to the direction in which it is turning. The result will be exactly what would happen to a planet moving according to Kepler's laws: a diminution in orbit means a shorter time of revolution, and *vice versa*. Accordingly, when the field is excited all electrons rotating in one direction will suffer a shortening of their periods, while those turning oppositely will show a corresponding lengthening. Thus a single spectral line is split into a "doublet" whose components will, moreover, be found to be circularly polarized.

The obvious difficulty of this simple explanation arising from the fact that naturally only a very small proportion of the electrons would be found vibrating in circles oriented as presupposed, disappears when we remember that any vibratory motion is resolvable along three axial directions and that the simple harmonic vibrations along either of those perpendicular to the field is resolvable into the circular motions above described. The third vibration is in the line of the field and therefore not influenced by the magnet; hence when the phenomenon is viewed transversely there is a third component in the position of the original line.

It is hard to overestimate the importance of this discovery by Zeeman, leading as it has, on the one hand, to the brilliant researches of Hale and his co-workers on magnetic fields in the sun, and, on the other, to the explanation of many of the effects of magnetism on light.

Most of these effects have to do with polarized light and are allied to the Faraday rotation above mentioned. This experimenter established the fact that when plane polarized light traverses any transparent substance in a magnetic field—the direction being parallel to the lines of force—the plane of polarization suffers a rotation. The effect, which is analogous to that produced by a naturally active substance (*e. g.*, sugar solution), varies in amount with the character and thickness of the material, strength of field, wave-length of light and certain minor factors. Practical use has indeed been made of this well-known phenomenon in connection with a "massless" photographic shutter suitable for use in experiments on the photography of projectiles in flight. The light passes through a

nicol prism and is thereby polarized, so that when it reaches a second nicol "crossed" on the first no light is transmitted. Between the two is a tube of carbon bisulphide—a strongly magneto-optic substance—in a helix of wire. The passage of a momentary current magnetizes the helix and rotates the plane of polarization of the light passing through the carbon bisulphide sufficiently to permit the passage of a flash of light through the second nicol.

This effect, moreover, is not limited to transparent substances, for the magnetic metals, particularly iron, have enormous rotatory powers when specified in terms of a centimeter thickness. Indeed, if light could penetrate a centimeter into strongly magnetized iron it would suffer no less than five hundred complete revolutions of its plane of polarization, but the opacity of such substances is so great as to prevent the use of a film of thickness much greater than the ten-thousandth part of a millimeter, so the actual rotation is of the order of only a degree or two. Gases and vapors, especially of sodium, may also produce considerable rotations as shown by the extended experiments of Wood.

For the last dozen years, the writer has made a special study of this subject of rotatory polarization in its various phases. The rotation has been determined for a variety of substances as dependent on the wave-length of light used, not only for the visible, but also for a portion of the long wave, or infra-red, spectrum. The study has not been limited to transparent substances, but has also included the magnetic metals, particularly for the case of reflection (Kerr effect) for various directions of magnetization. Of late the work has been extended to include a comparison of the magnetic with the natural rotation, such as produced by a sugar solution, for a number of active substances. The experimental work has not been without its difficulties; for the eye must necessarily be supplanted by the bolometer when working with the infra-red radiations, and this, with its entailed accessories, makes up an apparatus rather complicated in comparison with the relatively simple arrangement that suffices for the study of rotatory polarization in the visible spectrum.

The results are naturally divided into two groups, according as they are for transparent substances or for the magnetic metals. The magnetic rotation of practically all representatives of the former class shows a rapid diminution with increasing wave-length as far as the writer has been able to investigate in the infra-red, that is, to a wave-length some three times

longer than any the eye can see. The rotation for wave-length 2μ (.002 mm.) is less than one tenth of what it is for sodium light. The dispersion curves for different substances are much alike and are in general quite similar to the natural rotation curves (for such of the substances as are naturally active) over the whole spectral region examined. The temperature coefficients of rotation are, however, quite different in some cases.

The metals present a more interesting, as well as more complicated, case than transparent substances. As Kerr showed, half a century ago, when polarized light is reflected from the polished surface of a highly magnetized steel mirror the plane of polarization suffers a slight rotation. This effect has been investigated by a number of observers for the visible spectrum and by the writer on the infra-red side. The rotation-dispersion in the visible spectrum is "anomalous," that is, the effect increases with longer wave-length instead of diminishing as does the rotation in transparent substances. Carrying the curves into the infra-red, however, it is found that the effect soon reaches a maximum and then diminishes rapidly for still longer wave-lengths. Viewed as a whole, the curves resemble very strongly the type of dispersion curve we are accustomed to associate with transparent substances in a spectral region of strong absorption, and it may be that for these metals, *e. g.*, iron, nickel and cobalt, the visible spectrum is a region of similar abnormal properties.

There are a number of other magneto-optic phenomena—some of them requiring experimentation with films of metal less than one-millionth of an inch in thickness—which the writer and others have investigated. In general, however, it may be said that light, while unquestionably magnetic and electrical in nature, yields rather grudgingly to experiments attempting to probe this relationship, and one must frequently content himself with small effects. The explanation of this undoubtedly lies in the fact that the tiny electron whose activities not only give rise to light, but, moreover, determine or modify all the optical properties of bodies, executes its enormously rapid vibrations in magnetic fields of its own which are exceedingly large. To influence these vibrations by our gross experiments with fields which must, after all, be relatively small, is accordingly a difficult matter.

DUST IN INDUSTRY

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THERE are only a very few distinct diseases or diseased conditions which are strictly speaking occupational in origin, such as the specific metallic poisonings, gas and fume poisoning, "Caisson disease" caused by working in compressed air, an anthrax infection from working with infected hides or wool. Other diseases, just as serious and just as truly due to improper working conditions, may be directly traceable to occupational hazards, however, though they may also be caused by or aggravated by other conditions outside of daily work. In these latter instances it is often hard to tell just how much of the trouble is due to faulty working conditions and how much to faulty personal hygiene of the worker at home or elsewhere. As working conditions and manufacturing processes differ so widely in different countries and even in different localities in the same factory, observations made at one time and place do not necessarily hold good as the basis of generalizations. To rightly judge of any industry and of its effect on health studies must not only be made in one place or one factory but in many factories in different localities.

A number of such investigations have been conducted in specially dangerous industries and have resulted in very greatly improved conditions, and in several of our very large cities special clinics have been instituted to treat occupational diseases and to make further studies of working conditions.

Some employers take every precaution they know of to lessen danger to their workmen, not only for the sake of the workers, but because employers are coming more and more to realize that a healthy, vigorous worker is even more valuable than a piece of machinery kept in good repair and well oiled. On the other hand, there are a great number of employers whose only aim is to secure a greater production in less time and at less cost, and who fail to appreciate the drawback to such an aim that unhealthy workmen, poor light, clutter and dirt really are. Bearing these facts in mind, one can see the value of intensive studies of health-hazardous industries in various localities, so that we may learn if possible the part

played in disease production by the special hazards and how far these hazards may be lessened or removed, or the workers protected from their bad effects. Among non-specific disease-producers found in industry none is of much greater importance and more generally prevalent than dust. Many industries necessarily are associated with dust in large quantities and often of very irritating nature, though too often much more dust is produced than necessary and that which is produced is scattered over a far wider area than need be.

Dusts produced in industry may be of various kinds and their harmful action on the system depends on the nature of the dust as well as on the amount. These dusts have been classified in several ways. First, as to whether they are mineral, metallic, vegetable or animal in origin, or mixed, but this grouping gives no definite idea as to their action. From the health standpoint a better classification is into irritating, poisonous and infectious. Dust in the air we breathe is inhaled and if insoluble may act more or less as an irritant to tissues with which it comes in contact, depending on the shape and hardness of the particles, hard, sharply pointed or angular particles like flint or steel being much more harmful than smooth clay or soft vegetable or animal fiber dust. Such insoluble dust, particularly animal fiber or hair dust, may carry into the system with it the germs of infectious disease, and many fatal cases of anthrax have been caused by inhaling the dust liberated in the sorting of infected wool or hides. Tubercle bacilli are often thus introduced on dried or drying particles of sputum carelessly expectorated by infected workers.

Soluble dusts are dissolved in the mucus covering the linings of the air passages and may act locally as chemical irritants, causing local catarrhal inflammations, which in turn lower the resistance of the tissues and facilitate the lodgment and growth of pus-producing bacteria, or the poison may be absorbed into the system and cause general poisoning, the most frequent examples of the latter being the numerous cases of lead poisoning occurring among painters, sand paperers and makers and users of white lead, red lead and litharge.

It is remarkable how much dust one can become accustomed to with apparently very little harm being done. This is partly due to the action of the excellent defenses nature has provided. Large heavy particles very soon fall to the floor and if the place of generation of dust is below the level of the nose or mouth of the worker these particles may never reach the respiratory passages unless they are thrown upward with force. Of those

particles of irritating insoluble dusts that reach the nasal openings and are inhaled fibers of any length are apt to be caught and retained by the hairs in the nostrils, while a certain percentage of the larger and medium-sized masses and even some of the smaller ones are deposited on the moist membranes of the nasal passages and eventually swallowed with the mucus from the back of the throat or sneezed or blown out of the nostrils. Only the finer particles penetrate to the trachea and bronchi, and there any that lodge on the walls of the larger air passages are swept upward by the current of mucus kept in motion by the countless little whip-like processes of the cells lining these tubes. So finally only the smallest particles, one authority says those under $\frac{1}{100}$ millimeter in size, reach the lungs themselves. Lehmann, working with white lead dusts, found that from 35 to 43 per cent. by weight of that entering the nostrils reached the lungs, the rest either being finally swallowed or breathed, blown or sneezed out of the nares. Insoluble dusts that do reach the finer bronchioles or air cells are taken up by wandering cells or phagocytes and carried into the tissues, or by means of their sharp edges or points work their own way in and there give rise to local inflammation, followed by an increase of fibrous connective tissue, especially marked around the small blood vessels and air passages. This firm nonelastic fibrous tissue replaces the normal more elastic tissue and crowds and contracts the small air passages. The former prevents the normal expansion and contraction of the lungs with respiration and the latter causes dilation of the terminal air cells due to increased resistance to expiration and hinders the normal flow of blood in the lungs, so lessening the amount of oxygen taken up by the blood and the amount of carbon dioxide given off. This slows up the normal tissue metabolism and lowers the general body tone, lessening resistance to disease, especially to infections of the respiratory tract. Such fibrosed lungs yield more readily to attacks of infective bronchitis and pneumonia, and many claim also that they make excellent soil for the development of tuberculosis, though when tuberculosis does develop it is more apt to be a slow chronic process owing to this very immobility of the lungs preventing the rapid spread of infection and giving nature more chance to build a protective wall around the diseased area. Some of the dust particles which the wandering scavenger cells carry into the tissues reach the lymph channels and are arrested in the lymph glands at the root of the lungs, where they remain out of harm's way and do no further damage unless infected. Such glands after death from

other causes are found swollen and loaded with gritty particles.

This brief sketch of the fate of inhaled dust shows the importance of dust prevention as a health measure in industry and the value of accurate data as to the volume of dust generated in different processes and the relative proportions of different-sized particles in this dust, as well as the shape and hardness of those minute particles which reach the lungs themselves. Such data as to the amount of dust inhaled have heretofore been very scarce and as a rule based on the amount of dust in comparatively small samples of air, at most a few cubic feet, and often small fractions of a cubic inch, and as air currents in rooms are constantly changing in force and direction, especially if there is much motion of persons or machinery, and as dust production in manufacturing processes varies from moment to moment, such small samples give no reliable picture of actual conditions. The investigators of the New York State Ventilation Commission two years ago developed a new testing apparatus by means of which much larger samples of air can be examined, such sampling extending over appreciable periods of time, so that much more nearly average conditions can be obtained and more reliable conclusions and estimates can be made. This apparatus, the Palmer dust-collecting machine, is essentially an electrically driven centrifugal fan which aspirates a continuous current of air through a fountain of water in a specially designed bulb. All the particles of any but ultramicroscopic size which are floating in the air are retained in the water, a gasoline manometer enabling one to measure the rate of flow of air through the machine. After a test the water is drawn off into a clean bottle and diluted up to a given volume. Knowing the amount of air sampled and the volume of water we know the volume of air that a given fractional amount of the water will represent. This water can then be evaporated and the residue weighed, to determine the weight of dust. The dried dust can be burned and again weighed to determine the proportion of organic and mineral matter present. Chemical tests can be made to determine the amount of any poisonous substances present and finally the dust particles can be examined under a microscope to determine their shape and size and number per unit of air, usually per cubic foot, as well as the relative number of particles of different sizes. For the last-mentioned purposes the commission recommends grouping particles in four or five groups, the smallest being about ten times the diameter of the average bacteria, and the largest about 400 times larger. Those under 0.001 millimeter

can not well be counted, and in the work to be referred to here have been disregarded, as they are considered too small to do any serious harm. With this apparatus, samples of from 25 to 200 cubic feet or more of air can be tested, the amount depending on the dustiness of the air. As the optimum rate of sampling is five cubic feet per minute, it will be seen that tests lasting from five to forty minutes give time for normal variations in air currents and dust produced to occur. In this way, the amount of dust per hundred cubic feet of air can be estimated in the shorter tests and actually weighed in tests of 100 to 200 cubic feet. As the average man inhales 30 cubic inches of air at each inspiration and breathes 17 to 18 times per minute, it is estimated that he would inhale about 18 cubic feet of air per hour or 144 cubic feet in an 8-hour working day. With these figures as a basis, it is easy to estimate the weight of dust and its percentage of organic and inorganic matter which a worker would inhale in his working day, of whatever length it may be, in his particular industrial occupation. Assuming that Lehmann's estimate of 42 per cent. of inhaled dust particles actually reaching the lungs and remaining there might be too high for some dusts, it is calculated that at least one third of inhaled dust would actually remain in the lungs.

Last winter the University of Pennsylvania Hospital established a clinic for occupational diseases in cooperation with the Pennsylvania State Department of Labor and Industry. In addition to the routine work of treating patients referred from industrial plants and to making special investigations of the working conditions of these patients, the clinic is engaged in a systematic study of dust hazards and distinctively dusty industries.

The study referred to includes surveys of the industries with determination of the relative humidity in the work rooms, as the amount of moisture in the air influences greatly the amount of dust remaining suspended in the air. Determinations were made, by the use of the Palmer apparatus described above, of the actual average weight of dust per cubic foot in the air of the work rooms, with the estimation of the total amount of dust a worker would inhale in a day's work. Estimations were made of the number of dust particles per cubic foot of air and these were grouped into four different sizes, with the determination of the percentage of each size in the total count, and the determination of the character of the dust, including shape of particles, percentage of organic and mineral matter and amount of any poisonous substances, if present.

Also physical examinations were made and medical histories taken of many employees, preferably of men who had been working a number of years in dusty trades. Finally the rœntgenologic department of the University Hospital made rœntgenographic examinations and radiograms of the chests of these workers, as that is where the effects of long-continued work in dusty atmosphere are chiefly seen.

The value of such work to the industrial physician, the worker and the industry itself can be readily seen. It is thought that a few of the results obtained and the conditions observed might be of interest to the general reader. For purposes of comparison and as a basis of standardization, air was examined in a suburban house and in a laboratory of the university to obtain an indoor standard, and outdoor samples were collected at the same places. The following table gives the number of particles per cubic foot of air, the weight of dust inhaled per working day, with the minimum amount retained in the lungs per day and per year of 300 working days in each industry examined. Each report is an average of tests taken in that industry in different rooms and departments and often in different factories. Sixty-five tests in all were made in nine industries and five tests for comparison which were calculated for twenty-four hour periods. The working days in the industries ranged from eight to twelve hours in length, the longest day being in the dustiest industry. Portland cement making was by far the dustiest trade investigated, and here the actual bulk of dust inhaled is amazing, but the reason for this will be seen when it is stated that from one room in one plant calculations showed that at least half a ton of cement dust and probably much more escaped into the surrounding atmosphere in a day. In a similar room at another plant, there were only about one sixth as many particles in the air, and of these a greater number were of the larger sizes, due to the exhaust ventilation stacks over conveyors which carried off many of the smaller, more dangerous particles. Men were found who had been working over twenty years in cement plants, and the table will show that they must have had from 2 to 4 pounds of cement dust lodged in their chests. Next to cement in the amount of dust created came plush and carpet making and here considerable variations were found in different rooms. The dustiest places were the wool breaker room where dirty raw wool was handled which might readily be contaminated with dangerous disease germs, and another room where old woolen rags of all descriptions were shredded up to be made over into carpet.

Results of Dust Tests in Industry

Industry	No. of Tests	Dust Particles per Cubic Ft.	Wt. of Dust Inhaled per Diem (in Grams)	Wt. of Dust Inhaled per 300-Day Yr. in Grams	Wt. of Dust Retained per 300-Day Yr. in Ounces	1 Lb. of Dust Retained in	Hours in Day's Work
Portland cement mfgr.	11 (2 factories)	6,790,900	0.4559 grams	146.77 grams	1.466 ounces	10.9 yrs.	12
Plush, blanket and carpet weaving	13	148,950	0.0906 "	27.18 "	0.291 "	56 "	10
Steel grinding	3 (2 factories)	578,100	0.0861 "	25.83 "	0.277 "	57 "	9.8–10
Flint grinding	3 (2 factories)	844,040	0.0663 "	19.89 "	0.213 "		8
Asbestos weaving	6 (2 factories)	494,130	0.0573 "	17.19 "	0.185 "		8–10.25
Felt hat making	3	126,020	0.0242 "	7.26 "	0.077 "		8
Pottery mfgr.	5 (3 factories)	182,720	0.0187 "	5.61 "	0.06 "		8
Cigar mfgr.	19 (6 factories)	102,600	0.0147 "	4.41 "	0.047 "		9.75
Silk weaving	2	87,000	0.0081 "	2.43 "	0.026 "		10
Indoor air average	3 (2 locations)	99,600	0.0492 in 24 hrs.	17.96 in 365 day yr.	0.173 in 365 day yr.		
Outdoor air average	2 (2 locations)	34,000	0.0299 in 8 hrs.	10.92 gm. in 365 day yr.	0.105 gm. in 365 day yr.		
Total	70						
Dustiest cement room		13,560,000	1.0644	319.32 gm. in 365 day yr.	3.419	4.7 yrs.	12
Dustiest wool room		430,400	0.7027	210.81 " " "	3.26	7.08 "	10
Dustiest steel grinding room.		1,066,200	0.1599	47.97 " " "	0.514	31 + "	9.8
Dustiest asbestos working room		356,800	0.1161	34.83 " " "	0.373	45 + "	10.25

Here too there was danger of infection as well as mechanical injury from dust. However, woolen dust itself is among the least irritating of dusts, far less so than the hard mineral dusts.

Steel and asbestos dusts are both decidedly irritating, the former being distinctively dangerous, owing to its sharp irregular form. In the dustiest streel-grinding room ball bearings were being dry ground between emery wheels and no effort was made to keep the fine particles from flying off into the air. The asbestos dusts would have averaged much higher except for the presence of very efficient exhaust ventilation hoods over the carding machines in one factory. As will be seen at the bottom of the accompanying table, one asbestos working room was even worse than the ball-grinding room. Flint dust, though ranking fourth in the table, is probably the most dangerous of all except possibly steel, and flint has a reputation for shortening the lives of workers and inducing tuberculosis. One flint mill has an exhaust system, but, as often is the case, it was not working. Pottery manufacturing has a bad name, but conditions were not found to be very bad, as will be seen. Formerly much lead was used in pottery glaze and is yet for some wares, but little was used in the factory visited, the employees being well protected when it was used, and a test of the dust showed only a small per cent. of lead present.

The danger in felt hat making is not so much from the fur dust itself as from the mercury dust, rising from the carrotted fur. The fur is "carrotted" or brushed with acid nitrate of mercury solution to prepare it for the felting process. Cigar manufacturing has a bad name for dust production, but, as seen in Philadelphia, this is undeserved and nicotine tests on the dust showed little or no danger of poisoning of the workers.

The silk factory was the cleanest place visited, and here there was less dust than found anywhere except in outdoor country air. This is partly due to the high degree of relative humidity maintained to make the silk fibers more manageable.

In many of the places where samples were taken relative humidity was tested, and in general it was seen that where there was most moisture in the air there was least dust and fewer large particles proportionately to smaller. Tests of relative humidity also showed that in few if any of the rooms was the humidity too high for comfort, though heat was excessive in many cases where testing was done in hot summer weather. In most instances the relative humidity might well have been artificially increased as a means of reducing dust. This could have been done by the use of humidifiers to add moisture to the

air or by supplying cool air in ventilation ducts by means of water sprays or circulation over cold pipes. The mere lowering of the temperature of air increases its relative humidity by lowering its saturation point.

X-ray examinations of the chests of workers in dusty atmosphere showed varying degrees of fibrous deposits in the lungs, as well as fine scattered shadows due to the dust itself. These while well marked in workers in cement and in steel grinders were distinct in potters only after many years of work. Shadows of less degree were also seen in old plush and carpet mill employees, which may have been due in whole or in part to the inorganic matter mixed with the fibrous dust in an old mill not kept any too clean. Evidence of damage to the lungs of cigar workers was absent even in the men working many years at the trade.

Dust conditions in many factories or in parts of factories were minimized by the introduction of strong local exhaust ventilation with hoods over dust-creating machinery, but these were by no means universal and where employed were not always properly constructed or of sufficient size and power, and at times were not even working. Where sufficient suction ducts were in operation the effects of exhaust ventilation on the various-sized particles could be tested and as would be expected it was clearly shown that in addition to lessening total dust it removed a portion of smaller, more dangerous particles.

In general, dust may be prevented or lessened by removal at the source as indicated above, by substitutions of wet for dry processes, by frequent vacuum cleaning or wet sweeping and by increasing relative humidity. In numerous cases dust-generating processes can be entirely enclosed in specially ventilated drums, boxes or rooms, so as to allow no dust to escape into the factory. Where dust can not be prevented dusty processes should be conducted in separate rooms and, especially if the dust is poisonous or very irritating, workers may wear masks or dust helmets. Almost always there can be found some way to protect the workers from excessive dust and such means will be more generally employed when such investigations as these prove more definitely the harmfulness or relative harmlessness of specific dusts and processes.

THE BANANA: A FOOD OF EXCEPTIONAL VALUE

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THE banana of commerce is the fruit of various species of *Musa*, a plant which develops abundantly throughout the whole tropical zone. Many species of *Musa* are known, differing in size and character, and their fruits likewise show differences in size, appearance and flavor. Various common names are given to the different varieties, such as red bananas, yellow bananas, apple banana, date banana, ladyfinger, etc. The banana found principally in the American market is the fruit of the *Musa sapientum*, of which there are a large number of varieties, the most common being the Gros Michel banana. The plants and their fruits differ considerably in appearance and actual composition, according to the environmental conditions of soil, climate and other geographical and geological features.

The banana constitutes the chief carbohydrate food, in fact the principal food of enormous numbers of people in many parts of the tropics, thus taking the place of cereals and tubers, such as wheat, rye, barley and potatoes, in the food relations of the temperate zone. Careful computations have been made by numerous authors showing that the actual amount of food material produced per acre in the cultivation of bananas exceeds that of wheat or any other crop. The banana is therefore to be considered not as a luxury but as a very important staple in the food supply of the world. From this point of view it deserves much higher consideration than it has hitherto been accorded.

Since the edible portion is surrounded by a thick enveloping skin it is effectively protected against the attacks of bacteria, moulds and other agencies of decomposition, therefore if the skin is unbroken it may always be eaten with the assurance of its sanitary quality and freedom from dirt or objectionable material.

THE COMPOSITION OF THE BANANA

Many analyses of the banana have been made by different investigators. Since we are especially interested in the Ameri-

can banana, it is probable that the average of the American analyses may best be quoted: Atwater and Bryant, working under the auspices of the U. S. Department of Agriculture, give the following figures, showing the analysis of the edible portion of the banana, U. S. Dept. of Agriculture, Bull. No. 28, revised edition, 1906, p. 71:

	Water, Per Cent.	Protein, Per Cent.	Fat
Minimum	66.3	1.0	.0
Maximum	81.6	1.6	1.4
Average	75.3	1.3	.6

	Total carbohydrate, Per Cent.	Ash, Per Cent.	Fuel value per lb.
Minimum	16.3	.5	330
Maximum	29.8	1.1	640
Average	22.0	.8	460

The banana as purchased contains, of course, a large amount of inedible material, the skin, which amounts approximately to 35 per cent. of the total weight. Since, however, bananas are ordinarily not purchased by weight, but by number, this does not enter into the general question of either cost or food value. The ash of the banana is principally made up of the phosphates, sulphates and chlorides of potash, soda, magnesia and lime, all of which serve useful purposes in the body economy. It is thus seen that the banana contains all the classes of food materials required for the animal body, although the amount of protein and fat are too low in proportion to the carbohydrate to constitute a perfectly balanced ration. The combination of banana with milk in proper proportion, or its utilization as a vegetable to supplement a diet containing a small amount of meat will produce a ration which is ample to take care of the body needs.

Comparison of Banana and Potato and Other Foods

A comparison of the banana with the potato is of particular interest. Again quoting from the carefully made tables of Atwater and Bryant, page 68 of Bull. No. 28, above mentioned, we have the following figures:

	Potato, Per Cent.	Banana, Per Cent.
Water	78.3	75.3
Protein	2.2	1.3
Fat	.1	.6
Total carbohydrate, including fiber	18.0	22.0
Ash	1.0	.8
Calories per lb.	385	460

It is thus seen that considering the edible portion, the banana approximates very closely the potato in analysis and ex-

ceeds it by about 20 per cent. in its fuel or food value. Without giving the detailed figures of analyses, it may be of interest to compare the food value of the banana with that of a variety of other foods which we have come to regard as almost indispensable in a properly regulated dietary. The following table from Bulletin No. 28, mentioned above, shows the calorific value per pound of edible portion, except as otherwise noted, of some of these foods, the average result being used in each case for comparison:

Banana	*460*
Spinach	110
Squash	215
Green peas	465
Onions	225
Parsnips	300
Cabbage	145
Green corn	470
Fresh lima beans	570
Beets	215
Macaroni, cooked	415
Boiled oatmeal	285
Asparagus	105
String beans	95
Carrots	210
Clams, raw	240
Lobster	390
Oysters, solids as purchased	230
Scallops	345
Haddock	335
Flounder	290
Halibut, as purchased	470
Bluefish	410
Chicken, broilers, edible portion	505
Pickled tripe	270
Round steak, very lean	540
Round steak, medium fat	950
Milk, whole, as purchased	325
Apples	290
Cherries	365
Figs	380
Grapes	450
Oranges	240

A casual survey of this table shows that the banana exceeds in real food value many foods of different classes which are in almost daily use, such as whole milk, boiled oatmeal, shellfish and other fish, and fresh vegetables. Comparison of the food value of bananas and meats, as for example, round steak, should not be made without calling attention to the fact that the type of food is different in the two classes. Meats are

essentially protein foods and as such are more adapted to the development of tissue than to the quick production of heat, while the banana, on the other hand, is less a tissue-forming substance but is incomparably more effective in supplying the heat-giving materials. In a crude way we might say that the proteins are the foods which make good the losses due to wear and tear in the machinery of the body, while the carbohydrates are the foods which keep the machinery in motion and do work. From this standpoint it is seen therefore that the banana, because of its higher carbohydrate content along with a certain amount of protein, would be a more useful all-round food than a pure meat diet in which the amount of carbohydrate is nil. A comparison with medium round steak, for example, shows in the edible portion in each case 65.5 per cent. water for the steak as against 75.3 for the banana, and protein content 20.3 for the meat and a fat of 13.6 per cent. as against the figures for the same constituents of the banana. On the other hand, the meat possesses no carbohydrate, whereas the banana has 22 per cent.

From the standpoint of the consumer the fairest method of comparison between these facts would be in noting the cost in cents per calories of fuel value obtained. At the present market price of meats the advantage is distinctly in favor of the banana. A similar comparison with fish is not without interest. Taking haddock as a food-fish now largely used, we purchase with each pound of fish approximately twelve ounces of water, that is to say, the haddock contains approximately 81 per cent. to 82 per cent. of water as against 75.3 per cent. in the banana. The fish shows a larger proportion of protein, but the fat content, however, is less than in the banana and there is no carbohydrate, wheras, as we have seen, the banana, is rich in this quick-acting, heat-giving substance. From the standpoint of calories, therefore, the banana exceeds the common food-fish considerably and from the standpoint of real costs the odds are greatly in favor of the fruit. If we compare the food value and cost of potatoes and bananas at the present retail price, $1.00 per peck and 25 cents to 30 cents per dozen, respectively, we shall find that of these two substances which are essentially similar in their analyses, there is a decided advantage in favor of the banana. At present prices, April, 1917, when purchasing bananas, one cent will buy 65.9 calories on the average, while in buying potatoes this sum secures 46.6 calories—a 40 per cent. difference in favor of the tropical fruit. In this connection it is perhaps well to call the attention to the fact that the banana can be cooked in a variety of ways and

may replace the potato admirably. It may be baked, boiled, fried, served as chips, or "French fried," and in all these ways is an excellent and highly nutritious article of food. For use as a vegetable in the ways just mentioned, it is found of advantage to use fruit which has not reached the state of full-ripeness as the starch content is then greatest and the sugars less, while for desserts and for eating in the natural state the rich sugary fruit is more acceptable.

Bulletin No. 7 of the Bureau of Public Health Education of the New York Dept. of Health, issued February, 1917, says:

The onion, like most green vegetables, is of value in the diet chiefly for the mineral salts which it contains. It is these and not its protein that make it a valuable addition to bread and meat. Bread and cereals and meat are described by the chemist as having an excess of acid-forming over base-forming mineral matters. Green vegetables and fruits are of the opposite character, having an excess of base-forming minerals. A proper balance of these two classes of minerals in the diet is essential to health. There is danger at the present time, when vegetables are unusually costly, that the health of the community may suffer from a deficiency of base-forming minerals in the diet. It is important, therefore, to call attention to the fact that apples, bananas and oranges, which have not greatly advanced in price, may be used as substitutes for vegetables. They contain the same mineral matters in varying proportions. Apples, bananas and oranges all surpass onions in their excess of base-forming minerals. On Saturday, February 24, a member of the Home Economics department of Hunter College investigated the prices of fruits and vegetables on the upper east side of Manhattan. A few of the prices, with some other facts, are given below:

	Avg. Cost lb.	Per Cent. Refuse	Avg. Cost per lb. Edible Portion	Food Units per lb. of Edible Portion
Bananas	$.04	35	$.054	460
Cooking apples	.04	25	.05	290
Small oranges	.05	27	.0635	240
Onions	.15	10	.165	220

It is therefore evident that these fruits are all cheaper than onions.

It is also clear that on the basis of food value, the banana is nearly a third cheaper.

An analysis made in the laboratory of the writer gave the following results:

ANALYSIS OF BANANA ASH

	Per Cent.
Silica	2.19
Lime	1.82
Iron oxide	0.18
Phosphoric acid	7.68
Magnesia	6.45
Soda	15.11
Potash	43.55
Sulphur trioxide	3.26
Chlorine	7.23

That is, the ash is largely made up of the base-forming salts, the carbonates, phosphates, chlorides and sulphates of potash, soda and magnesia.

Below will be found a table, which has been prepared from analyses shown in Bulletin No. 28, previously referred to, and from the data accumulated by Professor H. C. Sherman, of Columbia University, and other authentic sources, where is shown the analysis of a number of foods both of animal and vegetable origin and their comparative calorific value based on present prices. The costs per pound have been obtained as a result of a number of actual purchases made at retail in New York City and are therefore reliable.

The Nutritive Ratio

The nutritive ratio shown in the table may require a slight amount of explanation. This is based on the fundamental fact that proteins, carbohydrates and fats supply the actual food material to the body. Of these, protein alone is nitrogenous material, while fats and carbohydrate contain no nitrogen. Nutritive ratio really expresses the relation between the energy derived from the nitrogenous food and that derived from the non-nitrogenous nutrients and is determined by a computation of the calorific value of the proteins as compared with fats and carbohydrates. Since the fats have a heat-giving value which is approximately 2¼ times that of either carbohydrates or protein, the energy relation of nitrogenous to non-nitrogenous material is not an exact expression of the percentages of protein and non-protein, but of the fuel or power-producing value. The figures in the table therefore represent the real amount of energy derived from the total carbohydrate and fat calories as compared with the energy derived from the protein.

In this connection it should be explained, as suggested earlier, that the nitrogenous and non-nitrogenous foods serve somewhat different purposes in the body economy, since the nitrogenous foods are mainly for the repair of tissue, while the non-nitrogenous ones are for the development of power (energy). For this reason it is undesirable and uneconomical to have too much protein. Only the nitrogen actually needed for repair and building of tissue is utilized, the remainder being excreted. There is no storage against a future shortage as in the case of fat. Therefore in a properly balanced diet the amount of protein food should not ordinarily exceed 15 per cent. of the total fuel used. Moreover, the actual amount of fuel used varies

with age and occupation. Those doing hard manual labor need more energy and consequently more food. Growing children burn their food rapidly and need more protein in proportion to the total than do adults.

The general relation of foods to the body needs as well as their relative cost based on calorific value is well expressed in the following quotation from the bulletin on "Food: Fuel for the Human Engine," prepared by the recognized expert, Dr. Eugene Lyman Fisk, and issued by the Life Extension Institute of New York during the present year (pp. 5–6)

There are three main groups of fuel foods: Here they are in order of cost per calorie, *i. e.*, those giving the most energy for the money heading the list.

Starchy Foods	Sugars	Fats
Bananas	Sugar	Drippings
Cornmeal	Corn syrup	Lard
Hominy	Dates	Salt Pork
Broken rice	Candy	Oleomargarine
Oatmeal	Molasses	Nutmargarine
Flour	Most Fruits	Peanut butter
Rice		Milk
Macaroni		Bacon
Spaghetti		Butter
Cornstarch		Cream
Dried lima beans		
Split peas, yellow		
Dried navy beans		
Bread		
Potatoes		

About 85 per cent. of the fuel should come from this group, using starchy foods in largest amounts, fats next and sugars least. Fats, starchy foods and sugars are almost pure fuel, like coal, while cereal foods also contain some building and regulating material.

The same bulletin, presenting a table of the raw materials in common use in the order of their cost per pound, places bananas at the bottom of the list, *i. e.*, the cheapest food.

THE HIGH-POWER FUEL

The banana is not only a higher-power fuel for the body, but it is also rich in the desirable salts. The onion has long been considered a valuable food adjunct because of its mineral salts. The banana is even more valuable.

A little known commodity in America is banana flour, but in view of the shortage of materials it is one which should be seriously considered. The fully grown, but unripe banana, is the source as it is desired to obtain the carbohydrate in the form of starch before it goes over to soluble sugar. The peeled fruit is dried and ground, the water content is removed to approximately 15 per cent. and during this process the other ingredients are concentrated.

According to the eminent English dietetic expert, Dr. Robert Hutchinson in "Food and the Principles of Dietetics," we find:

The unripe banana is dried and used to produce banana flour or meal. A sample of such a flour had the following percentage composition:

Moisture	Moisture	Proteid	Fat	Carbohydrates	Mineral Matter
Banana flour	13.0	4.0	0.5	80.0	2.5
Wheat flour	13.8	7.9	1.4	76.4	0.5

I have placed alongside of it the composition of good wheat flour, compared with which the banana meal is rich in carbohydrates and mineral matter, but very poor in proteid. If rice, on the other hand, had been taken for comparison, it would have been found that banana flour was about equal to it in nutritious value.

The *Lancet*, February, 1900, in a discussion of the banana as food says:

For some reason not yet explained, the starch of the banana is much more digestible than are the cereal starches, besides which the fruit contains a notable proportion of nitrogenous material.

In a later article (*The Lancet*, October 17, 1903), this journal states:

There can be no doubt of the nutritious character of banana flour, and the starch in it is peculiarly easy of solution and digestion in the alkaline digestive juices of the body. Banana flour is readily dissolved, for example, by the saliva.

Dr. Hutchinson also calls attention in "Food and Dietetics" to the fact that dried bananas compare favorably with dried figs in nutritive value.

During the recent rise in the cost of foodstuffs, Dr. Graham Lusk, at the request of the New York State Board of Health, compiled a low-cost meatless dietary of high efficiency value. In speaking of this he said:

Potatoes with their valuable alkaline salts had to be excluded from the diet because of their prohibitive price.[1]

It is noted, however, that sliced bananas and sugar appear as a component of luncheon or supper. Many articles have appeared during the past ten years pointing out the high food value and the wholesomeness of this fruit.

The complaint is sometimes made that uncooked bananas are indigestible. Making a careful study of the subject, it is found that this statement is only partly true and should be modified to read that "uncooked, unripe bananas may be indi-

[1] *Science*, Vol. XLV., April 13, 1917.

Food	Refuse, Per Cent.	Water, Per Cent.	Total Indigestible Nutrients, Per Cent.	Digestible Nutrients			Ash, Per Cent.	Food Value			Avg. Time of Gastric Digestion, Hr. : Min.	Cost per Lb. as Purchased in Cents	Cost per 100 Calories as Purchased in Cents	Calories Purchasable for 5 Cents
				Protein, Per Cent.	Fat, Per Cent.	Carbohydrate, Per Cent.		Per Pound Calories as Purchased	Edible Portion	Nutritive Ratio 1:				
Bananas	35.0	48.9	1.6	.8	.4	14.3	.6	300	460	19.7	1:45	5	1.66	300
Beans, string	7.0	83.0	—	2.1	.3	6.9	.7	180	195	—	3:45	16	8.88	56
Beans, fresh Lima	55.0	30.8	—	3.2	.3	9.9	.8	255	570	—	—	9	3.53	141
Beets	20.0	70.0	—	1.3	.1	7.7	.9	170	215	6.8	3:45	15	8.82	57
Cabbage	15.0	77.7	.6	1.2	.2	4.6	.7	115	135	4.2	4:30	14	12.17	41
Onions	10.0	78.9	—	1.4	.2	6.5	.5	205	215	—	3:30	8	3.90	138
Potatoes, Irish	20.0	62.6	1.2	1.5	.1	14.0	.6	295	370	9.5	2:30	8	2.71	185
Potatoes, sweet	20.0	55.2	1.6	1.2	.5	20.8	.7	460	570	18.3	—	10	2.18	230
Squash	50.0	44.2	.4	.6	.2	4.3	.3	105	215	7.8	—	6	5.71	88
Tomatoes	—	94.3	.5	.7	.4	3.7	.4	95	95	6.6	2:05	15	15.79	32
Beans, dried	—	12.6	7.9	17.5	1.6	57.8	2.6	1,520	1,520	3.5	2:30	20	1.31	380
Apples	25.0	63.3	1.2	.3	.3	9.7	.2	220	290	34.7	1:30	5	2.33	215
Grapes	25.0	58.0	1.7	.9	1.1	13.0	.3	335	450	17.2	—	10	2.98	168
Oranges	27.0	63.4	1.0	.5	.1	7.7	.3	170	240	15.8	—	5	2.64	240
Strawberries	5.0	85.9	1.0	.8	.5	6.3	.5	175	180	9.3	—	20	—	—
Cod (dressed)	29.9	58.5	.5	10.8	.2	—	.6	215	325	0.1	—	10	4.65	108
Flounder	61.5	32.6	—	5.4	.3	—	.5	115	290	—	—	10	8.70	58
Haddock	51.0	40.0	—	8.4	.2	—	.6	165	335	—	1:30	10	6.06	83
Mackerel	44.7	40.4	.7	9.9	4.0	—	.5	365	645	—	—	25	6.85	73
Oysters (solids)	—	88.3	.6	5.8	1.2	3.3	.8	335	335	1.0	2:55	30	8.95	56
Milk, whole	—	87.0	.5	3.2	3.8	5.0	.5	310	310	4.3	3:15	5.5	1.77	282
Eggs, uncooked	11.2	65.5	1.1	12.7	8.8	—	.7	635	720	1.7	—	28	3.90	138
Beef, fresh :														
Round, medium	7.2	60.7	1.4	18.4	12.2	—	.8	890	950	1.5	—	30	3.37	148
Ribs	20.8	43.8	1.8	13.5	20.0	—	.5	1,135	1,433	3.3	—	20	1.76	284
Beef, roasted	—	44.1	—	22.3	28.6	—	1.3	2,805	—	—	4:15	—	—	—
Beef, dried and roasted	4.7	53.7	4.5	25.6	6.6	—	5.5	790	840	0.6	—	16	2.03	221
Beef, boiled and salted	—	38.1	—	26.2	34.9	—	.9	1,620	—	—	3:20	—	—	—
Corned rump	6.0	54.5	—	14.3	22.0	—	3.1	1,195	1,270	—	—	30	2.51	199
Veal cutlets	3.4	68.3	1.2	19.5	7.1	—	.8	690	705	0.8	5:00	22	3.66	137
Mutton, hind quarter	17.2	45.4	—	13.8	23.2	—	.7	1,235	1,495	—	3:00	25	2.02	247
Lamb, hind quarter	15.7	51.3	—	16.5	16.1	—	.9	985	1,170	—	—	26	2.47	202
Ham, smoked	14.0	34.8	—	14.2	33.4	—	4.2	1,675	1,940	—	—	30	1.79	279
Bread, white	—	35.3	2.9	7.8	1.2	52.0	.8	1,200	1,200	7.0	3:30	16	1.33	376

The outstanding fact that at once impresses the careful student of these and similar figures is that dried beans and bread alone are cheaper than the banana when measured in fuel value. The banana to-day provides more actual food for the same cost than any fresh fruit or vegetable, or fish, meat, milk or eggs.

gestible," for all evidence shows that the thoroughly ripened banana is not only digestible, but it is one of the easiest foods to digest in the whole dietary. Dr. Arnold Lorand of Carlsbad states that "as far as their digestibility is concerned I have personally noted that when eating a perfectly ripe banana it almost melts in the mouth when simply turned over several times without any actual mastication and only a few stringy fibers in the middle of the fruit will remain. In this way two or three large bananas may be eaten without there being any feeling of discomfort in the stomach. Of course bananas are only thus digestible when quite ripe; those still somewhat green are less so, especially when they feel hard on the outside, although when very well masticated they are easily dissolved." As a matter of fact, many people assume that when a banana begins to show brown or black spots on the skin it is past the period of ripeness, whereas it is approaching the point when it may be regarded as perfectly ripe.

Comparative studies on the length of time required for foods entering the stomach to be digested and passed on to the intestinal tract, have been published by numerous investigators. One which has stood the test of time shows the following figures:

Foods	Average time of digestion. hr. min.
Ripe bananas	1.45
Oatmeal	3.5
Beans	2.30
Cabbage	4.30
Onions	2.5
Green peas	2.35
Boiled potatoes	3.30
Tomatoes	2.5
Turnips	4.0
Vegetable marrow	1.45
Boiled beef	4.15
Roast beef	3.20
Roast mutton	3.15
Roast pork	5.20
Soft boiled eggs	3.30
Boiled fowl	3.0
Codfish	3.30
Mackerel	4.0
Apples	2.30
Nuts	4.0
Oranges	2.45
Plums	3.40

This table shows that of all these common foods the banana is the most readily digested. This is explainable by the fact which was previously mentioned, that in the mouth during the process of mastication the carbohydrate is largely transformed into assimilable sugar and the further process of transformation in the stomach requires but a relatively short time. A meal of steak and potatoes would be seen, according to the table given, to occupy approximately three and one half hours for the digestive changes of the mouth and stomach to take place, whereas the ripe banana fruit would be digested and ready for absorption in half that time. It has already been shown that the banana is actually richer in nutrients per pound of material than the common food-fish or the common food vegetables. The table just cited above shows that it also is a more easily digested food than fish or vegetables, requiring a shorter time period for the digestive fluids to act in order to bring it into usable form.

General Conclusions

The statements which have preceded should not fail to make it clear that in a period like the present when we are facing a general shortage of cereal and other carbohydrate food we may turn to the banana as one possible solution of our difficulty. The fact that bananas may be obtained in abundance throughout the year, that they may be shipped for long distances under suitable conditions without being impaired in any way, that they may be used either as a fruit or as a vegetable, cooked or raw, in their normal form or dried or powdered, shows clearly that in this remarkable fruit we have an adjunct to our dietary which should not be underestimated. Used in connection with dried beans or peas or with dairy products such as milk and cheese or with the lean meat, it serves perfectly to secure a properly balanced ration.

It is practically the only food which during the last two years has not shown a marked increase in price and to-day will stand comparison with any food upon the market on the basis of caloric costs. Everything points to its continued favor not merely as the "poor man's fruit" as it has sometimes been called, but as a staple food for universal use, and it is to be hoped that it will be employed in continually increasing amounts whether as a substitute for other foods which have become prohibitive in price or because of its own inherent quality.

RESULTS AND EXPECTATIONS OF RESEARCH ON FISHERY PROBLEMS

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TO speak of calories in the days before this war was to be outlawed as a conversationalist. Now the word is in the vocabulary of every housewife and even at the club or hotel you may hear men grumbling that they are fed on calories. With equal certainty we note the popular adoption of the scientific lingo of the engineer, the chemist and the statistician. In strenuous war times the people turn to science with renewed interest and confidence. They even submit humbly and expectantly to scientific dictation. It is hard to imagine the American public in peace times submitting to the admonition, "Eat more fish instead of meat," no matter how many statisticians might recommend it. Yet that slogan is warmly received now. Sometimes the public confidence in the victorious power of science is almost pathetic, as in the case of a hope for a submarine panacea. In the Utopian republic respect and confidence toward science would be based on knowledge of its power and progress and neither distrust nor overconfidence would hamper the usefulness of scientific results. That happy state does not exist, so that science should still take pains to make clear to the laity why research has produced and will produce results of benefit to humanity. During this wave of sympathy with science it is timely to show the justification for the expenditure of government funds and private endowments for scientific research and to state some of the needs for the future.

Results and hopes of any one of our large and productive laboratories in state or endowed universities or in research institutions would alone give a fitting exposition of the human usefulness of research. With equal propriety one might choose the work of any or all of our government bureaus. My own experience gives me opportunity to know some of the results and aims of the United States Bureau of Fisheries. The description of the scientific work does not pretend to completeness or any sort of cataloguing, but merely to presentation of a background for the suggestion of possible lines of future effort. There is no intent to imply that the Bureau has announced its

purpose to pursue the problems here stated. They are merely the problems which through conference with various members of the bureau's staff and through my own researches have come to my attention. They are taken from all portions of the field of biology.

General biological surveys and intensive observations of the flora and fauna of waters in restricted areas have proved their usefulness. Of course much of the work of that character has served to locate fishing grounds. In some cases an abundance of fish of certain species not previously used could be pointed out. For example, the biological surveys of the continental shelf of our Atlantic seacoast revealed the presence of tilefish. Subsequent observations, extending over a period of years, made it possible to record their catastrophic decrease in numbers followed by their slow increase, so that when fishermen were persuaded to go after tilefish abundant schools were found at once. Within two years after the first shipload of tilefish was brought into port the supply in the markets of New York and Boston amounted to nine millions pounds annually. This constitutes a real addition to our food supplies. Biological surveys show so great an abundance of the species, extending over so large a habitat that fishing activities are not likely to deplete them. Barring unpredictable circumstances tilefish should be a staple commodity in our markets. Similar results may be expected from surveys locating beds of sea-mussels. Though treated as a great delicacy by European culinary art the mussel has not been appreciated here. A demand, stimulated chiefly through the efforts of the Bureau of Fisheries, is being created. Extensive beds located in many of our coastal waters are being mapped out. They could yield a satisfactory supply. If this knowledge were used to good advantage by the shell-fisheries industry another important addition to our food resources would be made. At this time, when clam digging has in so many communities been worked almost to the extinction of the clam and when the oyster industry is complaining that many of their most productive waters are no longer available for oyster culture because of pollution, we must find some means of increasing our supply of edible shell-fish. While efforts are directed toward the development of improved methods of clam and oyster culture, we must also avail ourselves of the ocean's munificent supply of sea-mussels. A slightly different type of useful result is seen in the introduction of the manufacture of ornamental "artificial ferns" from marine hydroids. A knowledge of the location of these growths made it possible to build up a considerable industry.

These three examples are selected from many which might show the value of biological surveys as carried out in marine investigations. As a matter of fact, the vast resources of the ocean have scarcely been touched. The more we can know about them the better shall we make use of them. Some of the specific problems of this type that are awaiting investigation include the determination of the causes of fish migration, of the abundance of certain species during certain years, of the scarcity of some species during longer or shorter periods over areas sometimes very large. Why should mackerel be so marvelously abundant for a few years during the '80s and then be comparatively scarce for nearly thirty years, reappearing again in huge schools all along our New England coast? Similar variations in the abundance of many of our common fishes are on record. We ought to know whether they are due to changes in food supply, to meteorological conditions, to fluctuations in ocean currents, to fish diseases, to variations in the suitability of breeding conditions, or to other causes. Extensive oceanographic observations, especially biological surveys, including a study of the ultimate sources of the food of fishes and the distribution of many species at different seasons must be made. Since the higher forms live at the expense of the lower ones explanations of the food supply of fishes must include a study of the microscopic life of the sea. It seems probable that bacteria and diatoms, those minute vegetative forms so generally abundant, are really the ultimate feeders for life in the sea. It is perhaps difficult for the casual observer to realize that filtering specimens of sea water day after day and month after month would yield material important in determining the migrations of fishes, but such observations to show the distribution of diatoms will in all probability help to solve the question of the distribution of all life in the sea. Not only the microscopic plants, but seaweeds, seem to possess fundamental importance in maintaining a supply of nutrition for marine fauna. To what extent the various common seaweeds play a significant rôle in what might be called the metabolism of the sea, remains to be determined.

Even compared to such general biological survey work, intensive studies in comparative anatomy and morphology have also yielded and will continue to yield significant results. Consider, for example, the importance of studies on the life history of the oyster. They have made possible the development of modern methods of oyster culture, an industry more highly developed in America than in any other country. Much re-

mains to be done to fill the gaps in our formation. What conditions are responsible for the failure to obtain during certain seasons a "set" of young oysters? Why were seed oysters once abundant in certain localities which do not now produce them? To what extent do oysters lend themselves to artificial hatching, so that the present occasional discouraging failures in the seed crop may be obviated? These are still among the unsolved problems of oyster culture now receiving earnest attention. It would not have been possible to attack them unless knowledge of the morphology and life history of the oyster were far advanced. Similar information on the developmental history of the clams and mussels is available. Its application to clam culture is just beginning and will no doubt become more important in the not distant future. The cultivation of sea-mussels is still an unknown art but when they are known for the delectable food they are, sea-mussel growing may also become an applied science. The story of the fresh-water mussel, how it is reproduced, how it becomes parasitic on the gills of certain species of fish, and while growing there is transported to a new habitat, how it then drops off, becomes "planted" and develops to furnish an article of great commercial value as the basis of the pearl button industry—all this constitutes one of the most interesting chapters in biology. It is a striking instance of the development and application of morphological investigation. Further work on the optimum conditions for reproduction, on the kinds of fishes which may serve as hosts during the parasitic period, and on other similar problems is going forward.

The developmental history of the lobster has been of equally striking use. A knowledge of the different molting stages through which the young lobsters pass made possible the devising of special cultural methods for rearing lobsters to a stage at which they are able to escape their enemies, hide beneath rocks, and, in short, take care of themselves. Artificially hatched lobsters reared to this stage may be liberated with some hope that thereby the depleted supply of this table luxury will be increased. Such researches on invertebrates, interesting as they are, seem small in the importance of their food productive results alongside the embryological and anatomical studies of food fishes. These are the basis of all fresh- and salt-water hatchery work. Future extensions of such activities will require amplification of our knowledge of the developmental history of many species.

Studies in fish pathology contribute their share to the success of fisheries. Here perhaps in better measure than else-

where are shown unexpected application of research supposed to be in pure science without practical usefulness. Long-continued observations on the occurrence of various species of parasites in a number of common food fishes made it possible to distinguish the harmlessness to human beings of certain of the parasites. When, therefore, health authorities of the city of New York, alarmed at the discovery of parasites in butterfish, seized so many of them in the fish markets that an estimated loss of $30,000 occurred within three days, the bureau was able to furnish decisive information. The parasites had been proved to be harmless and to have been present in a large proportion of butterfish as examined over a period of many years. The sale of these fish was therefore continued and a large food loss prevented. This is one instance. Other similar cases have occurred. A complete knowledge of the parasitology of fishes is desirable from the standpoint of safeguarding human food, but the application of this knowledge should not stop there. Fish pathology should be able to furnish information helpful in the work of increasing our supply of fish. It has been shown that some loss of food fishes certainly occurs as the result of parasitism and other fish diseases. The cure and prevention of infections in a number of kinds of fishes, notably those, like trout, occurring in limited bodies of water, has been possible. An almost unlimited field remains to be developed here for marine fishes. We have little idea as to what extent disease is a cause of their depletion. The nature and the prevalence of such diseases, the life histories of parasites, whether bacterial, protozoan or of other nature, must be worked out much more fully than has been done to date. With such information available it is to be hoped that means of control might be devised.

The work which the biochemist may do for the solution of fishery problems covers a varied field. The metabolism of aquatic forms has received some attention. The application of that knowledge to the maintenance of proper nutrition in fishes artificially reared and of suitable oxygen supplies in the water of fish hatcheries has been useful. If this country is to adopt, as prudence strongly advises, a more extended custom of rearing fish domestically in small ponds all the problems relating to the most economical and effective methods of nourishing fish in confined waters must receive more attention than they have had. The need of information about the physiology of nutrition of a specific aquatic form has already been emphasized. I refer to the oyster. It was formerly possible to obtain oysters in a

well-nourished condition, the so-called "fat" oysters, so as to supply the market adequately. The best nourishment for oysters, however, is found in those brackish waters around which growing population now tends to furnish pollution. Oyster beds have been forced further and further away in many localities from the best feeding grounds and successful oyster culture has become more difficult. Transplantation of stock to good feeding grounds has to be resorted to, the latter are overcrowded and the production of really well-nourished oysters is diminished. Oyster culture in certain European localities has come to the use of rapid, forced "fattening" in small ponds. The most efficient application of any such method can only be based on a knowledge of many possible foods for the oyster and a well-developed study of its metabolism. Such investigations have been fostered by the bureau for some years and need to be further extended. Knowledge of the nutritional processes in a few marine organisms will throw at least some light on similar problems connected with others and surely the metabolic histories of all forms which may be artificially reared will have their practical significance.

The work of the specialist in dietetics is required in fishery problems. Since the early work of Atwater on the composition of American food materials, including extensive studies of fish and shell-fish, very little has been done to determine the food value of fishery products. In recent years our ideas of real food requirements have been radically revised. We no longer speak merely of the protein requirements of the body. We distinguish relatively great differences in the food value of the proteins from different sources. These distinctions can best be made in accordance with technique now developed by elaborate and well-controlled feeding experiments. Food values, in short, have to be determined biologically. Almost no work of this sort has been carried on with the proteins of fish and shell-fish. We desire to avail ourselves as far as possible of the comparatively inexhaustible food resources in the ocean. Particularly do we hope to supplement our expensive proteins, replacing meats, in some measure at least, with fish. To what extent we should do that depends properly upon the relative food value for human beings of fish proteins compared with others. A similar problem in nutrition is the vitamine content and the presence of various metabolism catalyzers in fishery products. It has been stated, though not yet perhaps entirely proved, that cooked foods no longer contain the so-called vitamines which might be present in the raw product. This idea together with the seem-

ingly established fact that vitamines are commonly present in animal tissues has led to claims which need to be substantiated. For example a more extended consumption of raw oysters has been recommended. That this may be sound advice and that we may thus healthfully increase our ingestion of vitamines is perhaps true, but it ought to be proved. Similar investigations of many foods await, to be sure, an attack, but for none of them would the usefulness of results seem more immediate than in the case of fishery products. Nowhere else is there available so great a store of food from animal sources immediately and comparatively cheaply accessible. The tremendously valuable work on the general nutritional value and limitations of some of our great food staples, like the cereals and the dairy products, as it has been carried on by certain of the physiological laboratories of this country should soon be followed by similar studies on fish and shell-fish.

Investigations in industrial chemistry occupy by no means a minor field among fishery problems. The manufacture of fish glue, the best methods for the preparation of fish fertilizers, the manufacture and industrial utilization of a great variety of fish oils, the preparation of potash and other potassium salts, of iodine and bromine from giant kelp and other sea-weeds are among the well-known chemical engineering attainments concerned with marine products. In the present world-wide shortage of hides the utilization of various fish skins in the tanning industry has of late received considerable attention from the Bureau of Fisheries. Future developments of these efforts will no doubt be observed with considerable interest. In this group of industrial problems, however, much remains to be accomplished. One has only to observe the large amount of waste in the form of fish offal now discarded from the receiving docks of any fisheries establishment to realize that we have a long way to go before we reach true conservation. To what extent the organs of fishes may be capable of yielding internal secretions or other preparations of therapeutic value remains to be shown. Better salvage of fats and the preparation of fertilizing material by more economical methods are perhaps to be developed in the future.

Appreciated only by those having the true research spirit is the fact that the more fundamental the research problem solved, the larger the number of practical difficulties solved by it. Any fool can see what a knowledge of the laws of electricity means to the modern world, but it took the genius of a Franklin to prophesy the importance of electrical research in its early days.

Countless illustrations of practical applications of scientific knowledge are brought forward to show how science is justified in dollars and cents even if one refuses to justify it on the plea of satisfying the thirst for knowledge. The so-called "pure" scientist and the "practical" scientist no longer gibe each other. They have long since come to understand that the work of neither can attain its full significance for mankind without the other's aid. It would probably be extremely difficult to find a man who would like to classify himself exclusively as either a "pure" or a "practical" scientist. Indeed no one experiment or group of experiments constituting a single research, if conceived and carried out by a sane mind, is likely to be entirely lacking in either general scientific interest or practical human value—if only you can see the interest and value! Unfortunately a large proportion of the world does not. When once convinced they applaud, but they still demand to be shown the connection between research and life. That a study of surface tensions in an oil emulsion should reveal a method for the successful preparation of a delicious food out of a material that would otherwise be wasted is not easy to believe. A long jump of the imagination is required unless the intermediate steps are explained. It is simple enough. When various researchers had shown that a trace of sodium soap increased, by its surface tension effects, the permeability of tissues to water, it was to be expected that a very dilute soda solution forming a trace of soap in desiccated fish would enable it to soak up water rapidly enough to make possible the preparation in any kitchen of a delicious dish out of a decidedly unappetizing dried fish. Relationships of this kind as they appear out of a group of problems to one worker have been sketched in this paper. If one of the co-workers in every science laboratory or unit group of researchers would take the time and trouble to at least state what they believe they have accomplished and what they hope to do there might be on record a reliable answer to the questions of the interested public. This is being increasingly done in these days of the progressive magazines, but even yet information is still obtained too often through an irresponsible newspaper reporter—the modern personification of old dame rumor. If this paper makes clearer to any one the problems confronting fisheries research, or if it induces any workers to cooperate in the solution of them, its object is attained.

THE DIAGNOSIS OF POTENTIAL NEUROSIS

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THAT psychologists are alive to the need of the elimination of the mentally unfit from those recruiting for military service is shown by the recent plan of the American Psychological Association to examine all the men by means of a comprehensive set of mental tests before they are accepted. If the outline is adopted and psychologists are set to work the next question will be the selection of some series of tests of proper diagnostic value. In all probability intelligence tests will occupy a large part of the testing program, but there is one large group of individuals who should be eliminated that neither intelligence tests nor any physical examination would detect; namely, those who in a short time break down under the special strain that they are forced to undergo in active service. The number of such cases that have occurred make it exceedingly worth while to endeavor to detect such individuals before they are sent to the front. If discovered they could be given less strenuous work, but none the less important, they could be saved from mental disruption and the loss to the government would be obviated.

It does not take a psychologist to know that resistance to mental strain is a variable quantity as are all other physiological and psychological facts. Some individuals in the midst of a great amount of excitement can remain perfectly composed, seemingly impervious to the influences at work about them. Others are roused to react with greater vigor, but experience no apparent harm from their increased activity. Others are easily nettled by the slightest emotional excitement and recover but slowly and with difficulty. While we have no information on the characteristics of the individuals who are the first to succumb mentally, it at least seems plausible that those who can adjust themselves with least ease to additional mental strain would fall into this group. The selection of these individuals might be made by a test which would subject them to unusual mental exertion or shock; those being regarded as potentially neurotic who are unable to meet the situation by proper adaptations. This at least seems more hopeful than any classifica-

tion made on the basis of intelligence tests. Mental stability is by no means correlated with intelligence.

We have shown in our work on sound distraction[1] that the most significant phenomenon that is evident in experiments designed to find the effect of environmental conditions upon psychophysical activity is the adaptation of the subject to the change in experimental conditions. If one shows no observable difference in his response to two situations, it is evidence that adaptation is perfect, not that the two situations are identical, of equal complexity or equally desirable. If one manifests a difference in his response to two different situations, this difference is not a measure of the difference between the situations, nor a measure of how much they differ in their effect upon the subject; it is simply an indication of how far the change between the two situations is beyond his power of adaptation. The writer believes that this fact opens a promising method of showing individual differences in ability to meet exceptional situations, and is hopeful that some simple test along the line to be suggested later may be found to be useful in the present crisis.

As a suggestive illustration of our point we will show the different ways in which the subjects responded to noise distraction. The experiment consisted of giving an individual the task of responding to visually presented material by translating it through a series of codes and then reacting on the one of ten keys which the exposure and translation designated. Each response caused a new exposure so that the subject could work just as rapidly as he chose. After he had worked at this task for a period of twenty to thirty minutes loud noises were introduced, continued for some time and then stopped, the sitting ending with a period of about ten minutes of work in quiet. In another experiment the subject was given the task of memorizing paired-associates under both quiet and noisy conditions.[2] In both experiments records were kept of the breathing of the subjects and of the amount of pressure they used in reacting upon the keys. A brief comparison of the various ways in which the individuals responded in the memory experiment is given in the original article and will not be treated further here. We will, however, make a comparison of the individuals in the discrimination reaction experiment.

In this experiment there were twenty-one subjects whose records are available for our purpose. We have made a brief

[1] *Archives of Psych.*, 1916, No. 35.
[2] *Am. Jour. of Psych.*, 1917, *28*, 191–208.

of their records and present them in the table; the letters in the first column designating the subjects as given in the original monograph. The first column of figures gives the percentage of increase or decrease in the time records of the subjects when the noises were first introduced; the second gives the percentage of increase or decrease of the end of the noise period as compared with the beginning; the third gives a comparison of the time records after the noises stop with those in the latter end of the noise period. The next three columns give the percentages of increase or decrease in the keep pressure records when the same periods are compared. A plus percentage indicates that the keys were pressed with greater vigor. The last three columns in the same way give comparisons of the breathing ratios. The breathing ratios were found by dividing the expiration time by the inspiration time; and indicate, we believe, the extent to which the subjects articulated as tney worked.

TABLE

SHOWING THE PERCENTAGES OF INCREASE OR DECREASE IN TIME, KEY-PRESSURE AND RATIO OF THE BREATHING EXPIRATION TO THE INSPIRATION TIME DURING THE COURSE OF AN EXPERIMENTAL SITTING IN WHICH NOISES WERE INTRODUCED AS A DISTRACTION. A, first part of noise period compared with preceding quiet; B, last part of noise period compared with first part of noise period; C, quiet succeeding noise compared with last part of noise period.

Subjects	Time			Key-pressure			Breathing Ratio		
	A	B	C	A	B	C	A	B	C
O	— 2.5	5.2	— 5.0	29.3	—16.4	—21.0	7.28	3.7	— 9.5
P	33.0	—20.6	— 5.8	93.8	13.9	—56.1	19.2	—24.2	9.7
Q	1[illegible].2	—27.0	3.7	161.0	—21.6	—23.4	—11.4	54.8	—30.6
R	10.8	— 8.5	2.1	19.8	—10.0	—20.8	—37.1	25.9	15.9
S	10.4	— 7.9	3.3	18.3	8.0	—37.2	—19.7	18.2	— 4.8
T	—10.5	— 5.8	15.1	146.8	4.5	—32.4	—16.7	153.5	—52.9
Bl	0	—12.9	— 7.1	8.0	— 7.4	—12.0	48.4	—30.1	—10.7
Sp	2.1	—10.4	1.2	21.8	—12.3	— 8.7	22.2	2.5	— 1.5
Sa	6.8	— 3.8	1.5	9.7	—43.6	—17.2	3.4	4.4	—36.4
Br	9.9	—18.4	— 8.1	27.0	— 7.1	—14.0	— 7.8	28.5	—24.2
Bo	— 9.6	— 4.5	1.6	13.4	— 2.0	3.0	5.7	— 2.0	— 6.5
Ch	— 9.6	0	0.7	14.9	26.5	—22.9	20.6	14.2	—10.5
Cr	— 3.6	1.0	— 1.4	—22.8	—19.2	— 4.3	33.0	—22.6	— 6.7
Re	18.5	— 9.4	— 2.9	7.1	—18.1	—15.1	14.7	— 2.5	—13.7
Pf	25.8	—26.8	6.4	19.5	—17.6	— 4.0	8.8	— 1.0	19.8
Me	1.5	—10.7	2.6	0.6	— 3.7	2.5	1.8	2.4	—15.2
Ca	0.8	— 1.0	—17.2	32.5	— 5.7	—34.0	— 0.5	22.1	— 7.9
De	3.5	2.9	— 4.3	26.7	— 2.6	—16.2	31.7	4.1	—20.4
Hi	—10.9	1.5	— 1.0	9.0	—14.5	—10.3	32 1	33.3	—20.5
Kr	—12.8	— 2.9	9.6	37.7	—16.2	—34.3	—10.3	48.7	—24.0
Ta	9.3	—18.3	— 1.7	3.1	37.7	—14.2	21.4	120.3	—47.5

Of the twenty-one individuals thirteen showed a loss in efficiency when the noises were first introduced, seven showed a gain and one no difference. Of the seven who manifested a gain in efficiency, six showed that they were in a state of greater muscular tension because they pressed the keys with greater force when the noises were introduced, and five of the seven showed by their breathing that they articulated to a greater extent in the noisy period. Of the thirteen who showed a loss in efficiency all showed an increase in muscular tension, eight indicated greater articulation in the first part of the noisy period and ten in the latter part of the noisy period as compared with the first part. The second column of the table shows that only four do less in the latter part of the noisy period than in the first part, three of these being of the group who did better when the noises first came than they did in the quiet. Of these three (O, Cr, and Hi) O and Hi both pressed the keys harder and gave a higher breathing ratio. Cr pressed the keys progressively more lightly, but shows a strong initial articulation adaptation. He evidently was not much excited by the situation, he did not become tense, but simply chose the means of adaptation that was of service in the situation and successfully met the conditions at hand. Sixteen improve in efficiency in the latter part of the noise period, and of these only four do not show less muscular tension at the same time, while eleven show an increased breathing ratio and five a decreased. The third columns of each group of records show that most individuals relax after the noises cease. Eleven individuals show a loss in efficiency, nineteen show less muscular tension, and eighteen a smaller breathing ratio, *i. e.*, less articulation. It is possible that inability to relax after a strain would serve as a valuable diagnostic sign. It is perhaps no bad sign for one to be aroused by a situation, but if he can not adjust himself to the return of normal conditions he is wasting valuable energy and may be more likely to break down under unusual situations.

We have cited these cases to show the great variety of responses that are manifested by university students. It is likely that none of these were of the type who could not withstand considerable mental strain; academic training is in itself a good eliminating agent. In a random group of individuals it is certain that we should get even greater variation in response.

It may be thought that intelligence tests would serve the purpose we suggest since they aim to test an individual's reaction to a more or less novel situation; and, as a novel situation would involve additional effort on the part of the subject tested,

if he could not exert this effort he would of course fail in the test. This is true in a measure, but in intelligence tests the emphasis is placed upon adjustment to the novel and not upon the cost of the adjustment to the individual. An intelligence test might be of value as a task to be given the subject if a measurement could be made of the amount of strain the solution caused him and whether he recovered from the strain in a reasonable length of time. A measurement of the stress under which one is working is a very difficult and uncertain affair, even in an elaborately controlled experiment, and would certainly not be practicable in the testing of recruits. A more hopeful method would seem to be along the line of making the difference between two situations so vastly different in complexity that it would require a great effort in order to adapt oneself quickly to the one after having worked in the other. This would simply be an extreme of the situation offered in our distraction experiments. An individual who might react to a moderate change in the experimental setting with little or no loss in efficiency in the work at hand might, if the change was severe enough, show a great loss or even a breakdown. The selection of a task which would give an adequate record of efficiency and the creation of two experimental situations differing greatly in their effect upon the task in hand would be the problems to be solved. They do not seem to be beyond solution by any means.

The accounts of the initiatory rites of savages and of earlier civilizations abound in methods of testing the powers of physiological endurance of the young men. They recognized that a body resistant to fatigue and strain was essential to their life of hunting and warfare. Those who could not meet the tests were not allowed to play the part of a man, but were given easier tasks. To-day physiological and medical examinations are made in order to select those with able bodies, but this war has demonstrated that a large part of the strain placed upon the soldier is mental. War is no longer a match of physiological prowess, it is essentially a match of brain power. This makes it essential that we have a means of selecting the mentally hardy to take the leading parts in the conflict. Intelligence tests will probably play the rôle in the mental examination that the physiological test does in the body examination. It is, however, recognized that a medical examination is just as essential or more so than a physiological. If a man is infected with some disease he is eliminated; if he is incipiently or potentially a neurotic he should be eliminated with even greater care. At

present psychiatrists have no means of judging who can endure mental strain with impunity, and it seems an opportune time now to discover the means of making such a diagnosis. If no test can be used at present with enough confidence to make a selection of the recruits, tests that look promising could be made on all those examined and the records of those who succumb compared with the records of those who survive the strain. This would give data that would be valuable not only in war time, but also for use in vocational guidance in times of peace. In the event that such a procedure is adopted we trust that tests whose aim will be to eliminate those least able to adapt themselves to situations of unusual mental strain will receive the attention that they deserve in the testing program.

PLAN OF THE UNIVERSITY OF PITTSBURGH.

THE PROGRESS OF SCIENCE

THE PITTSBURGH MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE meetings of the American Association for the Advancement of Science and the national scientific societies affiliated with it open at Pittsburgh on December 28. Careful consideration was given to the question of the advisability of holding scientific meetings in time of war. It was the judgment of the officers of the government consulted as well as of scientific men that such a meeting would contribute in important ways to national organization and preparation. A great part of the sessions will be devoted to problems directly concerned with the prosecution of the war and with altered conditions at home due to the war. Research in pure science will also have its place on the program. And this is as it should be, for when peace comes great responsibility will be placed on the scientific men of the United States to maintain the leadership in investigation which will probably have passed to us.

The great industrial city in which the meeting is held typifies the importance of the applications of science in modern life, while the rapid development of its educational and scientific institutions fits this city for a meeting of scientific men. The Carnegie Institute and the Carnegie Technical Schools, the University of Pittsburgh with the Mellon Institute, form a civic center in Pittsburgh admirably suited to the simultaneous meeting of a large number of separate scientific organizations.

The American Association held the last of its regular summer meetings in Pittsburgh in 1902. At that time the Carnegie Institute had been open seven years. The Schools of Applied Science had not been founded and the University of Pittsburgh was a small institution with scattered buildings. Under the directorship of Dr. W. J. Holland, in 1902 as in 1917 chairman of the local committee for the meeting; the institute has enjoyed a rapid development. The Schools of Applied Science have been built and liberally endowed. The University of Pittsburgh in 1908 acquired its present site and has begun the erection of the great group of buildings according to the plans shown in the illustrations. The Mellon Institute of Industrial Research, based by Robert Kennedy Duncan on a plan of industrial fellowships in chemistry representing a new method of education and research, has for about two years occupied its new building erected as a part of the development of the university.

In the course of the fifteen years since the previous Pittsburgh meeting, the association has developed as rapidly as the scientific institutions of Pittsburgh. At the time of the meeting in 1902, there were about 3,500 members, with a registration at the meeting of 435. There are now some 14,000 members of the association, and there will meet with it at Pittsburgh more than twenty national scientific societies which have become affiliated with the association. The meeting at Pittsburgh may not be as large as was the meeting in New York a year ago, when there were some three to four thousand scientific men in attendance, but the programs will certainly be of more than usual interest.

The subject of the address of the retiring president Dr. Charles R. Van Hise, of the University of Wisconsin, will be on the "Economic Effects of the World War in the United States" and many of the discussions before the sections of the association and the special societies will be concerned with problems relating to the national emergency and with national preparedness. The addresses of the chairmen of the sections are:

SECTION A.—Luther P. Eisenhart. The Kinematical Generation of Surfaces.

SECTION B.—Henry A. Bumstead. Present Tendencies in Theoretical Physics.

SECTION C.—Julius Stieglitz. The Electron Theory of Valence and its Application to Problems of Inorganic and Organic Chemistry.

SECTION D.—Henry M. Howe. Some Needs of Engineering.

SECTION E.—Rollin D. Salisbury. The Educational Value of Geology.

SECTION F.—George H. Parker. An Underlying Principle in the Architecture of the Nervous System.

SECTION G.—C. Stuart Gager. The Near Future of Botany in America.

SECTION H.—Frederick W. Hodge. The Ancient Pueblo of Hawikuh.

SECTION I.—Louis I. Dublin. The Significance of our Declining Birth Rate.

SECTION K.—Edwin O. Jordan. Food-borne Infections.

SECTION L.—(Leonard P. Ayres absent—no address.)

SECTION M.—Whitman H. Jordan. The Future of Agricultural Education and Research in the United States.

THE GEOLOGICAL WORK OF PRESIDENT CHARLES R. VAN HISE

THE address of Dr. Charles R. Van Hise as president of the American Association for the Advancement of Science is on an economic subject. Since his election to the presidency of the University of Wisconsin in 1903, he has devoted himself largely to work in education and in economics, not, however, neglecting the geological researches in which he had attained such high distinction.

Due to Dr. Van Hise's early training in chemistry and metallurgy, and to his field work in pre-Cambrian regions, his dominant interest in geology has been in its chemical and physical phases. For many years he was engaged in the detailed mapping of pre-Cambrian formations in the Lake Superior country, during that time having published, with his associates, seven monographs of the United States Geological Survey. His interest in correlation problems involved in Lake Superior surveys led to a broader consideration of the pre-Cambrian of the United States, the results of which were broght together in a correlation paper (Archean and Algonkian) published in 1892, which was the first attempt to bring some order out of chaos in this field. While the correlations then proposed were based on necessarily incomplete data, and have been superceded in part by later work, his contribution to the subject marked an important step in advance which has been the basis for a great deal of the subsequent work on correlation.

Pre-Cambrian geology is inseparable from structural geology, and Van Hise's development of the principles of structural geology, published in connection with his principles of pre-Cambrian geology (1896), has served as a text on this subject for many years.

Closely involved in a study of the Lake Superior pre-Cambrian is the origin of the copper and iron ores, to which subject Van Hise has made many notable contributions. Enlarging his field studies of ores to cover the lead and zinc ores of the Mississippi Valley and other ores through North America, he was in a position in 1901 to present a general discussion of the genesis of ore bod-

ies ("Some Principles controlling the Deposition of Ores," *Trans. Am. Inst. Min. Engrs.*), in which he emphasized the relationship of ore concentration to the movement of ordinary ground waters, though recognizing other agencies as effective. While more recent studies have modified his conclusions in some particulars, his contribution to the subject remains to-day as probably the best known presentation of this point of view.

In connection with the studies above mentioned, Van Hise found it necessary to consider the problem of metamorphism of rocks, and out of this came his great monograph on metamorphism, in which the subject was for the first time presented systematically and intelligibly to the general geologist. His broad outline of metamorphic zones, conditions and processes has been the basis for much of the development in metamorphic geology which has proceeded since that time.

In the fields of pre-Cambrian correlation, genesis of ores, structural geology and metamorphic geology, Van Hise's contributions have been in each case distinctive in their systematic presentation and perspective. Even where treating previously known subject matter, his vigorous and comprehensive style brought the subject home in such perspective that much of the subsequent work along these lines has been strongly influenced by his work. He drew his pictures with bold, incisive lines, which challenged attention. Some of the salient features of his investigations have been the classification of deformative processes on the basis of zones of rock fracture and rock flowage, the classification of metamorphic processes on the basis of zones of katamorphism and anamorphism, and the emphasis on the normal flowage of underground waters in connection with the concentration of ores. Later studies in all these subjects have required certain modifications of the general principles laid down by Van Hise, but in their broad outlines they still figure largely in the investigations of these fields of geology, and, even where not fully accepted, their influence is felt in the impetus they have given to advancement of knowledge in these fields.

THE COAL SITUATION IN THE UNITED STATES

At the present time, when the fuel situation forces itself upon the attention of every one, any discussion of the coal problem that goes into the causes of the present unsatisfactory state of affairs should receive a careful hearing. Such a discussion is to be found in a bulletin by Chester G. Gilbert, entitled, "Coal Products: An Object Lesson in Resource Administration," just published by the United States National Museum and constituting the third paper of the series, "The Mineral Industries of the United States," in course of issue by the Division of Mineral Technology of this institution.

The author points out the magnitude of the coal resources of the United States and the dependency of national welfare upon their proper development. Yet with more coal than is found in any other country, or indeed on any other continent, this country has long been dependent upon foreign sources for such essential products made from coal as dyestuffs, fixed nitrogen, and many important drugs; and is to-day, with the first pinch of war stress, uncertain whether the fuel needs of the American home can be met during the coming month. The American public has never faced these shortages as phases of a single problem, but has first become alarmed at the dye shortage, then over the nitrogen dearth, and now

shiver in anticipation of a meagre fuel supply.

To explain the present coal shortage by transportation congestion or labor difficulties is to offer a superficial cause. These dilemmas of course are the concrete means through which the trouble makes itself felt, but back of them stretches a far-reaching failure to work out a proper development for America's greatest resource. The trouble is not that insufficient coal is mined and transported, but that the present output is inadequately used. Our coal could be made to go a third further in meeting the nation's needs.

Progress in coal utilization depends fundamentally upon the production of more coke. At present the situation is limited by the needs of the iron industry. The quantity and type of coke thus far produced has been determined by its metallurgical use. Sporadic attempts to apply metallurgical coke to household purposes have met with failure and placed coke in an unfavorable light. Coke must be made of such kind as to be suitable for domestic use. This can be done; and the accomplishment is an urgent necessity. Domestic coke, in reality, will be artificial anthracite.

There is room in our industrial system for a greatly changed utilization of coal; in short, for "coal" to be used in the form of anthracite, artificial anthracite (domestic coke and steam-engine coke), metallurgical coke, gas for illuminating and power purposes, benzol for automobile engines, and at the same time made to yield a sufficiency of nitrogen, dyestuffs, explosives and other coal-product chemicals. There is present need for all these products. The problem is to make the necessary readjustments, such as may be done through the development of domestic coke, the application of coal-gas to power-plants, the adaptation of benzol to automobile engines, and so on. When this is accomplished, the fuel efficiency of our coal supply will be 25 per cent. greater, transportation difficulties for domestic fuel will be lessened, and in addition the country will be cultivating a wide range of industries, giving employment to labor and using the part now wasted of our most important single resource. These by-product industries growing out of proper coal development will serve to render the nation industrially independent in a great many essentials in agriculture, pharmacy, photography, textiles, disinfectants, explosives, refrigeration, painting, paving, water-proofing, wood preservation, and in an ever-widening circle of requirements.

Such an attainment will require a long process of organized adjusting. It can not be legislated into existence. It is a matter wherein the government can take the lead by shaping a suitable economic policy. It is particularly a matter wherein enlightened public opinion can contribute by appreciating the situation and directing action toward proper industrial coordination and growth.

The solution of the whole coal problem, in short, does not consist in cutting down industrial activities to meet present coal output, nor in circumscribing the scale of economic life to fit present misdirection of coal resources, but lies in working toward an industrial situation that will both permit and demand a widespread treatment of bituminous coal so as to yield on the one hand a smokeless fuel, an artificial anthracite so to speak, suitable alike for the home and the factory; and on the other a host of by-products essential to the industries of the nation.

SCIENTIFIC ITEMS

We record with regret the death of Dr. Franklin P. Mall, professor

JEAN GASTON DARBOUX.

Professor of Mathematics in the University of Paris and permanent secretary of the Paris Academy of Sciences in whose death France loses one of the group who have given that country distinction in mathematics.

of anatomy in the Johns Hopkins University and director of the department of embryology of the Carnegie Institution; of Dr. Richard Weil, professor of experimental medicine in Cornell Medical College; of Professor Edward Hull, F.R.S., late director of the Geological Survey of Ireland; of Mr. W. Duddell, F.R.S., the electrical engineer, and of Professor C. E. Bertrand, the plant-anatomist and paleobotanist of Lille.

SIR J. J. THOMSON has been nominated by the council of the Royal Society for reelection as president. Dr. William Gilson Farlow, professor of botany at Harvard University, has been elected a corresponding member of the French Academy of Sciences.—The anniversary address of the New York Academy of Medicine was delivered on November 15 by Dr. Henry Fairfield Osborn, LL.D., president of the American Museum of Natural History, on "The origin and nature of life."

A SPECIAL board of chemists to investigate explosives, the uses of gases in warfare and to act as advisers to the Bureau of Mines, has been appointed. The board will study the problem of increasing the production of materials used in explosives manufacture and will advise the bureau in the operation of the recently enacted law regulating the sale of explosives. The members are: Dr. William H. Nichols, of the General Chemical Company, New York, chairman; Professor H. P. Talbot, head of the chemical department of the Massachusetts Institute of Technology; William Hoskins, of Chicago, a consulting chemist; Professor H. P. Venable, of the University of North Carolina; Professor E. C. Franklin, of Stanford University, and Dr. Charles L. Parsons, of the Bureau of Mines.